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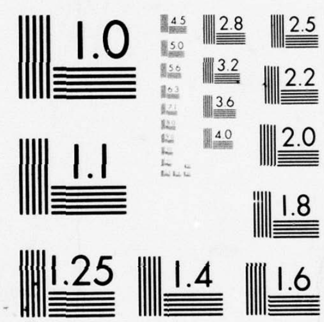

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Technical Report No. 993

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DESIGN OF PRELIMINARY FIELD TESTS FOR THE LOGISTICS-OVER-THE-SHORE (LOTS) TEST AND EVALUATION PROGRAM

6 January 1976

Authors: C. Collins, G. Holiday, W. Sutherland

Prepared under
Contract Number MDA-903-75-C-0016
For the Office of the Secretary of Defense,
Deputy Director, Defense Research and Engineering
(Test and Evaluation)
Washington, D. C. 20310

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1400 SPRING STREET
SILVER SPRING, MARYLAND

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Amphibious	Cargo	Containership
Bargeship	Causeway ferry	Crane-on-Deck
Beachhandling	Container	DeLong "B" Barge

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

During FY 1975 a Test Definition and Feasibility Study for a joint Logistics-Over-The-Shore (LOTS) operational test was accomplished by ORI under contract to the Deputy Director of Defense Research & Engineering (Test and Evaluation). The study defined a joint test program to evaluate the ability of the Services to conduct LOTS operations and identified a need for essential equipment and procedural preliminary tests to be carried out before the main test could begin. This report primarily addresses pretests and objectives for

19. KEY WORDS (Continued)

Distribution System	Lift Beam	LOTS	
Elevated Causeway	Lighterage	Merchant ships	
Embarkation	Load	MHE	
LASH	Logistics	Off-shore discharge of ships	
Pretest	Ship Off-loading		Test and Evaluation
Roll-on/Roll-off	Ship-to-Shore		
SEABEE	Temporary Container Discharge Facility		Throughput
Sealift Readiness Program	Terminal operations		

20. ABSTRACT (Continued)

the deployment and establishment of LOTS systems elements in the operating area, and interface with the distribution system. The objectives are intended to verify by physical demonstration the capability to load and off-load (in-port and off-shore) ships representative of the basic type specified in the test definition and to assist in the refinement of LOTS main test design. Test lifts selected for demonstration included heavy, outsized, mission-essential LOTS system equipment. The report also addresses measures of effectiveness, measures to be tested, data collection, and pretest scheduling.

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I. INTRODUCTION

BACKGROUND

During FY 1975, a Test Definition and Feasibility Study for a joint Logistics-Over-The-Shore (LOTS) operational test was accomplished by ORI under contract to the Deputy Director of Defense Research & Engineering (Test and Evaluation) (DDR&E T&E).[1] The purpose of the study was to define a joint test program concerning the ability of the services to conduct LOTS operations and the means to accomplish it. One of the study tasks was to identify any essential preliminary tests of equipment or procedures to be carried out before the main test conditions were fixed. Section V of the ORI study identified, in general terms, several individual pretests considered necessary to verify main test concepts and to minimize the risks of major interruptions or delays. Following completion of the Test Definition study, the DDR&E (T&E) has indicated his intention to conduct the joint test program under its general guidelines and tasked ORI to develop the pretest design and perform other project support functions related to test monitorship.[2]

PURPOSE

In order to verify the feasibility and assure the continuity of an operational test in which succeeding activities are largely dependent on the successful accomplishment of major preceding events, it is desirable to conduct a series of preliminary tests. Certain LOTS operations are relatively routine and do not require formal pretesting (such as the handling of conventional breakbulk cargo). Other LOTS techniques and concepts have been physically demonstrated

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[1] Operations Research, Inc., Feasibility and Definition of a Joint Logistics-Over-The-Shore (LOTS) Operational Test, ORI TR No. 913, 30 April 1975.

[2] Office of the Deputy Director, Defense Research & Engineering, Conduct of Joint Operational Test of Logistics-Over-The-Shore (LOTS) Capabilities, ODDR&E Memorandum, 26 June 1975.

under certain controlled conditions and pretest requirements are limited (such as crane-on-deck and crane-on-platform operations). However, LOTS system deployment by merchant ships is one key area where only very limited data is available. The introduction of new ship-types and newer and heavier LOTS system equipment has contributed to the data voids in the critical area of deployment capability. The pretest approach which follows is primarily concerned with the deployment phase of the joint LOTS test. Certain other areas relating to cargo discharge and distribution are included but in less detail.

SCOPE

This report deals with the pretest design task only, and emphasizes those pretests involving ship load and off-load evaluations. An appendix covering pretest of the LOTS application of the Standard Port System will be published at a later date. The report is provided to guide detailed operational test planning, particularly as it relates to the acquisition and scheduling of the longer lead time test equipment, ship charters, and other arrangements. It provides test target schedules, initial ship-equipment match-up for testing, an outline scenario of the ship load/off-load test events, procedures for test conduct, and the pretest measures of effectiveness.

II. SUMMARY

OVERALL OBJECTIVES

The purpose of the joint LOTS test program, concerning the ability of the services to conduct Logistics-Over-The-Shore operations, is to provide meaningful information that can be used by the services to:

- Alter or confirm established equipment requirements, operational techniques, and planning factors.

- Determine the best force structure for most efficient use of manpower.

From a systems viewpoint, meaningful test and evaluation of LOTS capabilities must include more than merely discharging cargo from ships in an off-shore environment. As a minimum, it must also address the deployment and establishment of LOTS systems elements in the operating area and the interface of the LOTS system with the supply distribution system ashore.

PRETEST OBJECTIVES AND APPROACH

As indicated in the LOTS Test Definition Study, the increased size and weight of LOTS container handling and transportation equipment may significantly limit the type of commercial ships capable of sealifting these components and discharging them at a marginal port facility or off-shore. Also, most of the newer merchant type ships have never been operationally tested in a deployment mode.

The basic LOTS pretest objectives relate primarily to the deployment phase of the evaluation. They are intended to verify, by physical demonstration, the capability to load and off-load, in-port and off-shore, ships representative of the basic types specified in the test definition study. Loads will consist of selected, heavy, outsized, mission-essential LOTS system equipment. The ship and equipment match-up for pretesting is reflected in Figure 1.

SHIP TYPE / LOTS EQUIPMENT	BREAKBULK SHIP	SEABEE	LASH	CONTAINERSHIP 140T CRANE	CONTAINERSHIP TANDEM 140T CRANES
LCM 8	●	○	●	●	○
LCU	● 1/	●			
LARC - LX	● 1/	○			● 2/
LACV 30	●	○	●	●	
CAUSEWAY	●	●	●	●	○
DE LONG "B"		●			
CRANES					
250 T					
ASSMBLD		●			
TAC DISSY	● 1/				
ADMIN DISSY	●		● 3/	● 3/	○
140 T					
ASSMBLD	○ 1/				
TAC DISSY	●		●		
TOPLIFT LOADER	●		●		
SIDE LOADER	●		●		

1/ HEAVY LIFT SHIP ONLY

2/ RECOMMENDED ONLY IF OPTIONAL LIFTS REQUIRED

3/ CRANE CARRIER ONLY

● – RECOMMENDED

○ – OPTIONAL

FIGURE 1. SHIP-EQUIPMENT PRETEST MATCH-UP

It is not the purpose of this phase of field pretesting to attempt a physical validation of a ship's total capacity, to optimize LOTS system deployment loads, to achieve any requisite degree of unit or system integrity[1/], or to ascertain the total capability of current sealift assets to deploy system equipment. All these areas will be addressed in the overall LOTS deployment evaluation which will be conducted subsequently.

The type test loads for each ship are derived from a combination of considerations which include:

- Inclusion of one of each major LOTS system components which appears technically feasible for deployment by each of the basic ship types for testing.[2/]

- Availability (in terms of both time and quantity) of the LOTS system components for load/off-load tests.

- Avoidance of test lifts of items which appear clearly within the capability of the ship type involved unless required to verify some aspect of load interface or assist in off-shore ship-to-shore movement and beach operations (e.g., 20-ton rough terrain crane and dozer).

- Holding ship-use portion of pretest to a reasonable minimum. The high cost of ship charters dictates some compromise of maximum desired test duration versus minimum required test events. All ship pretests envision a dedicated-use vessel, however, it is recognized that types not available in the MSC controlled fleet may be available only in a concurrent-use status.[3/]

- Minimum modification of ship and test load equipment configurations. Emphasis is on test match-up in an "as is" configuration, although certain adapters (e.g., lift beams, special slings, cargo flats, and load spreaders) as well as modified techniques (e.g., side lifts, overhanging loads) may be required. In some instances, critical mission essential equipment can only be lifted by certain type ships after disassembly. In other instances, some minor dimensional reduction will be required without major component disassembly.

[1/] System integrity is, however, a desirable goal even in pretesting, and to the extent that other considerations in test design would permit, it has been provided for. (Although not pursued as an objective initially, a "bonus" effect may be realized in the sense that each pretest ship "load" will include a nucleus LOTS "system"— i.e., ship off-load capability, ship-to-shore capability and beach discharge capability.)

[2/] A few of the lifts which appear to be feasible from a preliminary analysis require more detailed engineering evaluation to set parameters.

[3/] Limited pretest events may be undertaken during a time when the ship is still engaged in commercial operations.

PRETEST DESCRIPTION

As indicated in Figure 1 the ship-related pretests are a series of individual subtests involving the in-port loading of one of each of the compatible extra heavy and outsized items of mission-essential LOTS system equipment aboard each of four basic merchant ship types. Following the on-load phase and recording of test data, each pretest ship will deploy to a nearby anchorage in moderate off-shore water where test loads will be discharged using organic ships gear or auxiliary cranes, as appropriate. For certain selected LOTS system equipment, (e.g., beach cranes), that require disassembly and incremental loading, at least one ship pretest will include its ship-to-shore movement, reassembly, and demonstration of its operational status. Container handling evaluations may be integrated with appropriate ship subtest providing that deployment test objectives are not jeopardized or additional ship charter costs incurred.

The five primary ship subtests are to be conducted in the Hampton Roads Virginia area (Ft. Eustis - Ft. Story complex) during the period March - September 1976. The duration of the five subtests will range from two to five days each and a total of approximately 17 ship charter days will be required for their conduct.[4/]

Pretest concepts are optimized in that they envision the dedicated use of MSC nucleus or controlled fleet vessels, or commercially chartered ships for one continuous test period. Due to the fact that ships in the latter category may only be available for more limited periods or available concurrently with normal commercial operations, certain pretests may have to be conducted on an incremental basis.[5/]

Although not specified in detail, shoreside (non-ship) preparatory engineering checks are recommended prior to certain ship pretests. These include dummy loading of cranes at pretest lift weights and operational radii, trial loading of crane components into landing craft and subsequent water movement, crane disassembly and assembly, etc. It is anticipated that some of the pretest checks will be accommodated as part of the terminal service company (container) training program.

MEASURES OF EFFECTIVENESS

As indicated in the LOTS test definition study, one of the three overall measures of effectiveness identified for the LOTS main test was System Deployment Response Time. This is a comprehensive measure which must be calculated. In addition to the data acquired in the field pretests, it must also include data that is <u>not</u> test-generated, such as total merchant ship capabilities and availability,

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[4/] The LASH subtests will be combined with service evaluations extending the overall duration to seven days.

[5/] Dedicated use is considered relatively assured for conventional heavy-lift breakbulk ships and RO/RO ship (alternate). Forecast for availability of dedicated SEABEE is also favorable. Incremental testing, if required, will probably involve the LASH and containership.

as well as overall deployment requirements and ship arrival schedules in the objective area. Thus the measures for the pretest will be inclusive to the overall measures, and an essential part of their ultimate composition. The fundamental pretest measure of the ship-related experiments will be success or failure in accomplishing the load/off-load events summarized in Figure 2. To expand the scope of what is essentially a "go/no-go" evaluation, other related measures of factors that can serve as a basis for extrapolation will include:

- Time required to load/off-load each test item[6/]
- Material and manpower requirements to accomplish each test load/off-load
- Operational conditions and environmental parameters under which pretest events are conducted
- Mechanical stresses on test equipment and gear (to ascertain potential risks/operational limits).

DATA COLLECTION

The scope and nature of the ship pretests, and the fact that demonstration/verification of feasibility implies essentially a non-numerical result, will limit the data collection and processing task during this phase of the LOTS test program. Functional test measurements will not generally involve repetitive events or the requirement to process a large volume of measurements.

Unlike the main test, the nature of the pretest will involve a significant element of qualitative measurement. Consequently, the technical experience and judgment of data collection personnel should be a major consideration in their selection.

It is anticipated that most pretest data will be manually recorded and processed. Detailed photographic coverage will be used to supplement and document test results. Instrumentation recorders will be used to record mechanical stress measurements and environmental data on test conditions.

PRETEST SCHEDULE

Figure 3 is a target schedule for the conduct of the ship-equipment pretest described in this report and selected service tests that are related to the current LOTS program. The schedule should be considered tentative insofar as it is based on receipt of major new LOTS system equipment in accordance with current delivery forecasts and assumes the timely availability of ships for testing on a dedicated-use basis.

[6/] Where a ship pretest description also provides for the movement ashore and reassembly of LOTS system equipment measurements, these events should be included in "off-load."

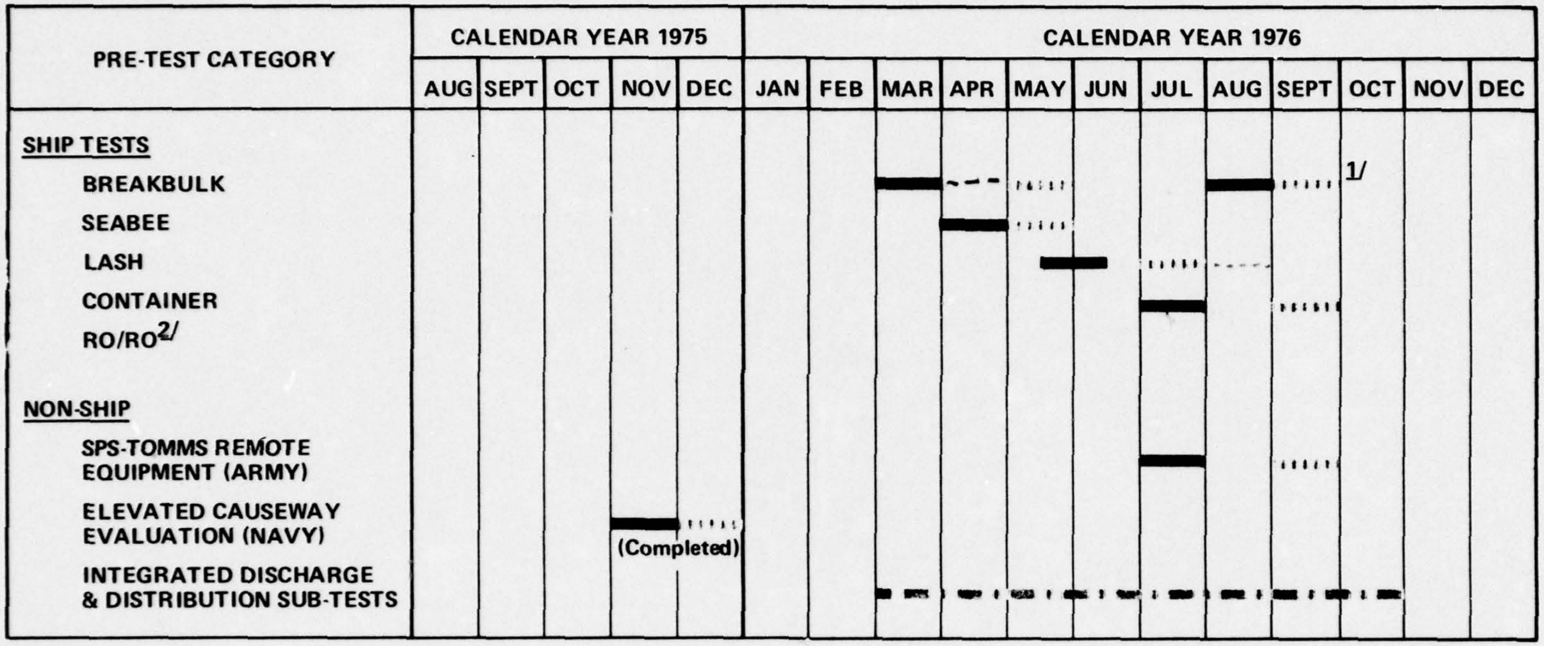
SHIP TYPE	SHIP DAYS	TEST LOADS[1/] ( ) OPTIONAL	TEST PRIORITY[3/]	SHIP TYPE	SHIP DAYS	TEST LOADS[1/] ( ) OPTIONAL	TEST PRIORITY[2/]
BREAKBULK	(3)	1 - LCM - 8	1	CONTAINERSHIP	(5)	1 - LCM - 8	1
(CONV. -70T BOOM)		1 - LACV - 30	4	(140T CRANES-ON-DECK)		1 - LACV - 30	4
		1 - CAUSEWAY (3 x 15)	5			1 - CAUSEWAY	2
		1 - 250T CRANE	2			1 - 250T CRANE	3
		1 - 140T CRANE	3			(1 - LARC LX)	
		1 - TOPLIFT LOADER	6			(1 - 140T CRANE)	
		1 - SIDE LOADER	7				
BREAKBULK	(2)	2 - LCU	3				
(HVY LIFT - 240T BM)		1 - LARC - LX	4				
		1 - CAUSEWAY (3 x 15)	2	SEABEE	(3)		
		1 - 250T CRANE	1			1 - LCU	4
		(1 - 140T CRANE)				1 - CAUSEWAY	3
						1 - DE LONG "B" BARGE	1
						1 - 250T CRANE	2
LASH[3/]	(4)	4 - LCM - 8	1 & 2			(1 - LCM - 8)	
		1 - LACV - 30	4			(1 - LARC - LX)	
		1 - CAUSEWAY	3			(1 - LACV - 30)	
		1 - 250T CRANE	2			(1 - 140T CRANE)	
		1 - 140T CRANE	1				
		1 - TOPLIFT LOADER	5				
		1 - SIDE LOADER	6				
	(3)	3 - CAUSEWAY (3 x 15)					
		1 - WARPING TUG					
		2 - TENDER BOATS					
		1 - 30T CRANE					
		4 - LASH BARGES					

1/ DOES NOT INCLUDE CERTAIN MHE, VEHICLES & SUPPORT EQUIPMENT WHICH MAY BE INCLUDED IN ADDITION TO SELECTED HEAVY LIFTS

2/ PRIORITIES ARE FOR GUIDANCE IN THE EVENT THAT INCREMENTAL TESTING IS REQUIRED. THEY DO NOT NECESSARILY REFLECT RELATIVE OPERATIONAL EFFECTIVENESS OR PRIORITY FOR EMPLOYMENT.

3/ INTEGRATED CINCLANTFLT EVALUATION MAY INVOLVE THREE ADDITIONAL SHIP DAYS.

FIGURE 2. PRETEST COMPOSITION, DURATION, AND PRIORITIES



1/ HEAVY-LIFT SHIP

2/ ALTERNATE TEST SHIP (NOT SCHEDULED)

PRIMARY TARGET MONTH

ALTERNATE TARGET MONTH

CONTINUING – WITH SELECTED SHIP TEST

FIGURE 3. PRETEST SCHEDULE

Other major factors considered in schedule development were:

- Approximately two month "shake-down" and shoreside checkouts after delivery of LOTS cranes prior to first pretest
- Sequencing conventional breakbulk ship first, based on its potential importance in a LOTS deployment role and the level of experience with this ship type
- Scheduling the SEABEE LOTS pretest to a programmed shipyard lay-up of the vessel in the Hampton Roads area
- Targeting the LASH test to coincide with the SOLID SHIELD 76 joint exercise with the objective of integrating LOTS pretest objectives and service objectives
- Deferring the containership pretest to allow more time for operator training and experience in crane operation
- Deferring pretest of the heavy-lift breakbulk ship (which has the most clearly demonstrated LOTS deployment capability) in the event resource constraints militate against its use prior to the main test.

The target schedule provides for major pretest completion by the end of the FY 1976-7T period and is the basis for test resource estimates. Any major pretest rescheduling will have to take into account differing climatic and other environmental factors.

III. PRETEST DESIGN

A. MEASURES OF EFFECTIVENESS FOR PRETEST OPERATIONS

QUALIFIED MEASURES SUITABLE FOR PRETESTS

Overall objectives of the series of tests— pretests and main tests together— include a determination of the capabilities to deploy LOTS equipment to an operational site and establish a cargo discharge and distribution system. Overall measures of effectiveness appropriate to this objective are:

a. The demonstration of capability (or deficiencies in such capability) to deploy each of the major elements that work together as an effective system during the LOTS cargo discharge and throughput operations.

b. The overall time for deployment: the total time required to make the ships available; load them with the appropriate LOTS system equipment; carry this equipment to the objective area; unload it; make it ready for use; and integrate it into a functioning cargo-moving system.

c. Measures of resource use, such as manpower and material requirements, fabrications, modifications in the operation, and the like.

The pretests described in this document address only segments of the overall deployment capabilities. Hence limited or qualified measures of effectiveness are appropriate for use in the pretests. The most important of these qualified measures are derived from the more inclusive ones outlined above. They are simply:

- The physical demonstration of capability to accomplish specific segments of the whole deployment operation

- The time required to accomplish each segment

- Assessment of the condition of equipment after each segment

- The man-hours used at various skill levels, expenditures of material for loading and securing equipment, etc.

The demonstration of capability implies a non-numerical result, and this will generally be the most important outcome for each pretest.[1/] Some numerical limits however may be derived from such tests. For example, a test event that was "successful" in sea-state two could be said to be possible for sea-states two or lower, or a test lift successfully made using a ship's 70-ton boom could be said to be applicable for booms with greater lift capabilities— or even with lesser capabilities— if the weight of the load is clearly within limits of the smaller boom.

The demonstration of capability also implies that the test "succeed" in accomplishing some result that has not previously been shown feasible, or for which there are potential obstacles. A "success" in a demonstration of capability is relative, rather than absolute, for the measure of success depends on how difficult the task attempted is, and the circumstances that surround it. Weather or seaway conditions, for example, could change a relatively simple task into a difficult one, or vice versa. Note, too, that a demonstration of capability that is successful in the sense of accomplishing the desired result may in fact have required the use of specialized techniques, unusual gear, or was inordinately time consuming, so that in the overall the "successful" pretest could result in the judgment that the tested concept not be used for the main test or has limited operational value.

A concept central to the demonstration of capability is that each of the pretest equipment-ship combinations has one or more problem areas that require special attention. The foreseen problems, such as small clearances, close-to-capacity weight, special sequencing of procedures, use of specially made slings, cradles, or blocking and bracing, and the like constitute the basic reason or reasons for making each pretest. These need to be analyzed before each pretest and after it has been completed. The analysis is intended not only to permit the pretest itself to go forward, but to be useful for the main test and

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[1/] For some tests, success in a particular event or endeavor is expressed numerically as a probability. This is appropriate when important factors affecting the result vary from trial to trial. Thus, the probability of success in hitting a target with a projectile or missile may be affected by aiming errors, variations in wind conditions, variabilities in propulsion, and the like. When measuring or controlling such factors is not feasible, their effects can be taken into account by using a probability approach. For the tests discussed here, probabilities do not appear appropriate because the important factors that affect capability, such as clearances, weights, and carrying capabilities are known (or at least knowable). (It is necessary to make the tests in order to guard against errors, unforeseen circumstances, safety hazards, unrecorded changes, etc., and to ensure that preparations for the main test are completed in detail.)

for possible future operations. (Note that a few of the pretests events are not necessarily the most desirable ways to accomplish the basic tasks. In contingencies the most suitable ship types, for example, may not be immediately available. Thus some of the tests have as their objective providing a necessary alternative that is admittedly less desirable.) The analysis should be made in sufficient detail to provide guidance for a similar operation (for example, aboard a ship of the same type but different design, or for other variations of the basic problem). Test documentation should show what the problem is, how in fact the problem is solved and the solution proved in the pretest, and what additional practical problems are encountered during the actual test. In the event the operation falls short of the expected results, a detailed account is required of what the circumstances were that caused the shortfall. This account should include such matters as the factors or range of the pertinent variables within which the operation could have gone forward.

The second measure, the time required to accomplish specific segments of deployment operations, is a numerical measure. Time is relatively less important as a measure than is the demonstration of success or failure. This is because the segments to be measured will be accomplished generally in fractions of an hour, while the total deployment will include times in days for acquiring ships and for sailing to the objective area. The relatively short time segments that will be measured will constitute a small fraction of the overall deployment time. (This is not to say that the events under test should not proceed at a realistic tempo and be accurately timed. Real operations normally are under a pressure of time, and the LOTS pretest operations must make effective use of the limited and expensive charter time of the ships involved.)[2/]

The man-hours, skill levels, rigging and tools needed, and material (like lumber expended for cradle cribs, cargo dunnage and similar uses) are to be recorded during the course of the pretests. Together with the problem description and its solution they will provide comparative information for the relative resources needed to accommodate various system components.

Measurements to be Made - Data Required

The data to be collected during the tests are in two categories. The first includes results of the functional measurements that are associated with the loading and off-loading of LOTS equipment and are outlined in Table 1 below. The second is a careful record of the conditions under which the functional information is collected, as outlined in Table 2.[3/] For a functional measurement to be useful, the conditions for which it applies must be known. Only then can the implications for future operations be assessed. This means that detailed records must be kept of:

[2/] It is recognized that in the pretests any number of artificial or administrative time delays may be incurred because of certain peacetime restrictions, safety precautions, test procedures, etc. Speed of load/off-load operations in the pretests is secondary to safety, need for test documentation and the like. Careful recording will permit the screening out of such delays to help predict realistic operational time requirements.

[3/] The tables contain certain unavoidable redundancies; these occur as a consequence of the format selected for them.

TABLE 1

FUNCTIONAL MEASUREMENTS REQUIRED FOR PRETESTS

Measure of Effectiveness	Measurement Required	Means of Measuring	Examples of Records to be Kept
Successful completion of test element	Assessment of individual test load events to include:	Observations, tape measures, scales photography, etc. (See separate table for list of test conditions and environmental measures.)	Description of the central problems anticipated and met, plus narrative description of the test events in log form, recording quantitative data on operating conditions, clearances, weights, and stresses. (Written or dictated observations.)
	a. Staging of test load	Observations of transfer methods, etc.	Needs for special preparations if any. (e.g., special ramps or platforms for load distribution or to provide ground clearance for cranes loaded into landing craft.
	b. Ship preparation for loads	Check of clear space available for equipment, condition of hoisting booms, etc.	For heavy loads, ship's calculated metacenter, freeboard list angle, placement of other cargo, holds and cargo booms used.
	c. Load preparation	Observations, tape measurements of state of equipment disassembly, folding, provision of lifting eyes, etc.	Description and sketches of equipment configuration (e.g., positions for cranes, welding of lifting eyes, lowering of vehicle windshields, etc.)
	d. Rigging	Sketches and observations of use of special bridles, use of tag lines, number of parts in lifting lines, tape measure, etc.	Record of attachment points, placing of fenders, tag line attachment to load, snubbing cleats for tag lines, position of cradles, sizes of lines and cables, angles they make with horizontal, etc.
	e. Test load lifting and positioning aboard ship	Observation and photography of lift.	Record of position of load in lighter and on board ship, clearances for tight fits.
	f. Securing of load	Observation, photography, tape measure	Record and describe position of loads and of tie downs, bracing, or other fastenings.
	g. Sailing phase	—	Record maximum degree of rolling or pitching if substantial enough to stress securing means. Observe action of securing means. Be prepared to photograph any deficiencies or excessive relative movement.
	h. Preparations for off-shore discharge	Observe and photograph mooring arrangements, lighter fenders, lighter location, etc.	Record arrangements for mooring, fendering, dunnage and load spreading devices in lighter. Record freeboard of ship and position of lighter along length of ship (at hatch no. 2 etc.).
	i. Test lift, and position in lighter (or launch lighter)	Measure distances travelled, approximate speeds of hoisting or lowering, and relative motions of ship, platform, and lighter (see test conditions entries in separate table below).	Record and photograph clearances, effectiveness of fenders, etc. (Note for this phase of operation relative motion of ship, platform, and lighter should be measured and recorded when sea state is two or greater. See entries on environment in separate table.)
	j. (for cranes only)		
	1. Ship-to-Shore movement	Observe position of lighter from pelorus measurements aboard ship.	Record position of lighter and time so as to record speed of lighter. Note throttle setting and rpms if available.
	2. Craft discharge	Tape measures and levels.	Record beach slope, draft of lighter fore and aft at beach, tide levels. Note techniques for moving dunnage, etc. Note any movement of lighter and clearance problems.
	3. Equipment reassembly	Observe and photograph critical operations	Record movement of crane, locations of booms and counterweights to be assembled, techniques used for assembly, and causes for any delays. Record time and manpower as separate entries below in this table.
Assessment of condition of equipment	Visual observation of possible damage, or limitations because of disassembly, counterbalancing, etc.	Observations. Photography if damage occurs or if disassembly, special folding of components and the like are necessary. Include not only equipment being deployed but also ship's gear.	Record needs for reassembly, removing of special counterbalances, cushioning devices and the like. For lighters, record time needed to start engines, remove lift gear etc.
Times required for specified elements	Elapsed times for important segments of individual test load events listed above	Continuously running watches, suitably coordinated.	Descriptive material in form of a detailed log, to include delays and reasons for them.
Resource Requirements	Recorded observations of:		
Skill Levels	Required skill and training levels of teams and individuals	Observation	Records of observation (observer must be familiar with skills).
Man-hours	Times worked (and tasks accomplished) by individuals and teams.	Watch and Observation	Log format records.
Tools, bridles, etc.	Record of use of slings, hooks, shackles, snatch blocks, etc.	Observation	Lists and sketches.
Consumption of fuel, lumber, rope, etc.	Recorded measurements	Scales, dip sticks, or meters. Estimates, rather than measurements, are suitable for rope and lumber.	Record of measures of weights, volumes, or dimensions of consumables.

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TABLE 2

MEASUREMENTS OF CONDITIONS DURING PRETESTS

PURPOSE OF INFORMATION	FACTORS TO BE MEASURED	SUGGESTED MEANS OF MEASURING AND RECORDING	PRETEST TO WHICH MEASUREMENTS APPLY
1. Assessment of hazards, risks, and physical limits applying to operations as a consequence of test loads or induced by environment. The assessment will generally compare measured stresses with designed load-carrying capabilities, using appropriate factors of safety, but will also evaluate more subjective dangers	A. Load Limits on Lines and Structures		
	(1) Stresses in primary load-carrying members (such as cables, booms, pins, and decks) that occur as a consequence of test loads, with inertial increments attributable to motions induced by waves.	Measurements of deflections, strain gages, or line tension gages.	Confined to selected pretest operations that involve near-limit loads--ones, for example, that are on the order of 80% or more of nominal capacities.
	(2) Impact stresses occuring during movements of LOTS system equipment.	Accellerometers installed on equipment or in lighters.	To be used only if there are questions of adequacy of stressed material to withstand impacts.
	(3) Angles and loads that are close to capsize limits:		
	a. For ships and lighters as a consequence of applying asymmetrical loads.	Levels or ship inclinometers, records of load applied, and tape-measure records of asymmetry of loading. Records of ship metacentric heights from information to be supplied by ship's master.	To be used when substantial tipping (i.e., more than about 4 degrees) has been calculated beforehand.
	b. For mobile cranes.	Weight and angle scales already installed in cranes. Comparisons of actual and predicted readings, and comparison with crane permissable-load plates are important.	All near-load limit tests using mobile cranes.
	B. Incidental Dangers and Risks Examples: personnel in potential danger from cables that may part, or from being between moving load and obstructions.	Written or dictated records by individuals designated to have safety responsibilities.	All tests.
2. Assessments of operational limits that occur as a consequence of environmental effects	A. Measures of Primary Environmental Conditions		
	(1) Wave heights and periods.	Wave measuring devices or recorders.	All tests taking place outside harbor.
	(2) Wind velocity & direction.	Ship anemometers & compass.	All tests.
	(3) Visibility.	Observations.	All tests.
	(4) Precipitation, temperature, etc.	Observations.	All tests.
	(5) Tide state, current direction, beach slope, etc.	Observations and tide tables.	All tests at beaches.
	B. Measures of Secondary Conditions Caused by Environment		
	(1) Ship and craft motion: pitch and roll angles and period.	Stop watch, ship inclinometer or other motion recording devices.	All tests taking place outside harbor.
	(2) Ship, craft, and platform relative motion.	Motion pictures to supplement analyses of absolute motion records. (Note: pictures not intended to provide accurate measurements of relative motion.)	Picture taking capability to be provided for all tests outside harbor. Actual pictures necessary only when relative motion is a definite hindrance to operation.
	(3) Momentary stresses in mooring lines, etc. caused by wave action.	Tension measuring devices.	Needed only for tests outside harbor. Measurement may be restricted to times when sea-state is 2 or greater. Measurements confined to primary lines that will be highly stressed, including crane main lifting cable.
	C. Effects of Primary and Secondary Environmental Conditions		
	(1) Slowdown of operations caused by need to take wave motions into account, to minimize impacts, or because of difficulties in making lines fast, etc.	Observations and stopwatch times that include readings in calm and again during sea-state occurence. Recording of operating difficulties such as caused by roll angles during spotting of lifts, problems in mooring lighters in a seaway, and pendulation forces.	All tests taking place outside harbor together with tests in calm water where pertinent.
	(2) Stresses resulting from motions caused by waves.	Stress measurements in crane components such as crane boom or crane outriggers.	Limited special tests of mobile cranes in operations on deck of rolling ship, to determine wracking in boom or boom fittings when lifting lines are not vertical because of sea action.
	(3) Incidental effects such as special care needed when precipitation has caused slippery footing, or from poor visibility.	Recorded observations.	All tests.
3. Data for use in applying test information to other ships or situations (also to check actual dimensions with available drawings, etc.).	Sizes of hatch openings, clear spaces on decks, sizes of fenders, weights of loads and of gear, number of parts in line, and size and angles of lead of highly stressed lines.	Tape measures, weighing scales, etc. Records of ship freeboard, draft, and locations and kind of cargo already on decks or in holds. Supplement with still photographs as part of technical record. Special care in recording unusual uses of dunnage or unusual angles required to fit equipment into confined spaces.	All tests.

- Factors permitting assessment of hazards, risks, and physical limits for equipment and gear. Such assessments consider the relationship between applied loads or forces and equipment capabilities.

- Environmental conditions and their consequences. These measurements and observations include primary environmental conditions such as wind velocity, sea state, and visibility; the differing secondary conditions that the primary conditions induce in different ships and lighters (such as motions and heel angles); and the effects of primary and secondary conditions on the operations.

- The physical circumstances inherent in the loading and discharge operations, such as clearances, weights, ship freeboard, ship list angles, etc.

Use of Available Measuring Facilities

The costs of measurements and observations outlined in the tables should be kept to a minimum by using available capabilities. For example, cranes ordinarily have load indicating devices; ships have anemometers and inclinometers and other instruments; and government agencies can provide recordings of weather, tide, and wave conditions that may well be in sufficient detail for pretest purposes. Government-owned and operated instrumentation devices should be used where they are cost favorable.

Replication of Measurements

The basic information sought from a pretest is generally to verify that the specific operation being tried can be done within reasonable limits of time and resources. Once the capability is shown, a repeat under the same circumstances would have little value for verification purposes. (Repeat tests under different conditions, such as a rougher sea-state, can of course add useful information but may be practically impossible to accomplish.) Further reasons for not repeating tests are the expense of ship charter time, and the difficulties of arranging for any substantial additional blocks of ship time. Both militate against repetitions of pretest events.[4/]

Reasons for repetition appear less compelling. They include:

- Finding the range of time that can be expected, as a way of assessing what delays must be expected and which ought to be discounted in using the data

- Assessing the effect of learning on the times required

- Trying variations and improvements in procedures

[4/] Comments not applicable to limited container-handling evaluations which may be integrated with equipment deployment pretests.

- Providing a more statistically viable base for comparisons with results for other circumstances such as the seaway mentioned above, and

- Providing the beginnings of a data base for predictions of capabilities and times for similar lifts of other equipment.

In general, repetitions are optional. If time is available for repetitions of single test events, they should be considered. If done, each pretest equipment lift should be separated from the previous test of the same equipment, so as to present "a whole new problem" the second time. For example, the delays in rigging a test lift should be given the opportunity to occur the second time, rather than simply repeating the test with the preliminaries already accomplished.

B. OPERATIONS TO BE TESTED

This section outlines some of the considerations in selection of operations to be tested. While the main purpose of this report is to describe the design of the pretests, the main test is also referred to in this section.

SCOPE

Some operations pertinent to a real LOTS situation will not be tested simply because the scope of the test has to be bounded by the availability of resources and time. For example, no tests are contemplated of the procedures used in nominating ships for the sealift, nor in emergency requisitioning of ships or containers. The testing envisioned generally concentrates on those operational aspects concerned with the far-shore part of LOTS operations, but does include investigation of ship capabilities to deliver selected LOTS equipment.

A second basic criterion for deciding whether an operation is to be a candidate for the proposed tests is that it be considered as an ongoing capability during 1977 through the early 1980s. The tests are basically intended to confirm and quantify projected in-being operational capability. Although developmental or research objectives are not central to the test design, its approach would not preclude testing certain combinations of equipment that have not been used together previously, nor equipment new to the system providing it meets the basic criteria for inclusion in an operational test program.

As plans for the various tests discussed herein go forward, it will be desirable to monitor the status of some promising LOTS developments that, as currently scheduled, will be too late for inclusion in the main test.

For some logistics-over-the-shore operations there is a minimum need for operational testing because capabilities are well established. An example is unloading breakbulk cargo from breakbulk ships. While breakbulk ships will perform an important function during the equipment deployment phase of the main

test, their testing is less central during the cargo discharge phase. (The objective is to provide for the introduction of breakbulk cargo concurrently with containers in order to test the capability to handle both simultaneously, rather than testing of breakbulk cargo throughput per se.)

PHYSICAL CRITERIA: WEIGHT AND DIMENSIONS

Physically, some equipment used in LOTS operations is not appropriate for deployment in certain ship types. For example, an LCU cannot be lifted with the heavy-lift boom of a conventional breakbulk ship. Similarly, some lighters cannot be used to carry certain equipment as their cargo during the deployment phase. For example, an LCM8 does not have sufficient load-carrying ability to transport in a minimum-disassembled configuration, the heavier of the two LOTS cranes being considered (i.e., 110 tons). The physical limitations of weight lifting or weight carrying on the one hand, and space requirements on the other, provide quantitative criteria that limit the number of ship-equipment and lighter-equipment combinations.

Dimensions and Weights of Equipment

Table 3 shows the dimensions and empty weight for LOTS equipment. The equipment selected are representative types of the largest and heaviest lighters, cranes, and MHE's that are expected to be available and that will comprise the nucleus of the LOTS "systems" in the late 1970s through early 1980s time frame. The list also includes barge types: the LASH and SEABEE bargeship barges, the DeLong "B" type barge, and the 100-ton capacity floating crane.

Weight and Space on Ships

Table 4 shows one aspect of the problem of carrying the equipment on shipboard— the capabilities of heavy lift ships, breakbulk ships, and bargeships to lift the equipment during loading or unloading. For each item listed (except the rough terrain toplifter, the sideloader, and the bulldozer, eliminated as being essentially less difficult to transport than the others), the table shows whether or not the shipboard gear could lift the equipment, and the margin of deficit of lift capability. Table 4 is the basis for eliminating some of the large number of possible combinations of ship-equipment possibilities for testing. Note that a "No" answer to the lifting capability eliminates the combination from consideration, but a "Yes" does not necessarily mean that the ship type could in fact be used for the transport of a particular type of equipment. This is because the table does not consider other possible limitations, such as available space, which is shown in the next table.

Table 5 extends the examination to the space requirements. It also shows one of the critical space considerations for RO/RO ships, i.e., the clearance through the largest roll-on port of the ship. In Table 5 those entries that had already been eliminated as too heavy (Table 4) are marked "Not Considered" (NC). There are additional NC entries for obviously impractical combinations, for example, the DeLong Barge on all ship types except the SEABEE.

TABLE 3

DIMENSIONS AND WEIGHT OF SELECTED EQUIPMENT IN LOTS OPERATIONS

		OVERALL DIMENSIONS, FT. & INCHES			
		LENGTH	WIDTH OR BEAM	HEIGHT OR DRAFT	WEIGHT EMPTY
LCU (1466 Class)		119'	34'	17'-9" HEIGHT	180 LTons 202 STons
LCU (1610 Class)		135'-3"	29'	17' HEIGHT	165 LTons 185 STons
LCM-8 (Steel)		73'6"	21'	14' HEIGHT 9'-5" MOULDED DEPTH	57.8 LTons 1/ 65 STons
LCM-8 (Aluminum)		72'-10"	19'11"	2'6" DRAFT FWD LOADED	35.7 LTons 2/ 40 STons
LARC 60		62'-6"	26'7"	15'4" HEIGHT REDUCED FOR SHIPPING	DRY 86.6 LTons 97 STons CURB 88 LTons 98½ STons
LACV 30		76'3"	33' (36½' on cushion)	21'6"	31 STons
Causeway Ferry (e.g. 3 Elements x 15 = 45 2/ Elements		90'	21'3"	5'-1"	60.3 LTons 67.5 3/ STons
DeLong "B" Barge		150	60'	10' DEPTH 3' DRAFT	800 LTons (Incl. Spuds)
LASH Barge		61½	31'-2"	8'2" DRAFT 15' HEIGHT	80 LTons
SEA-BEE Barge		97½	35	17' DEPTH 10'7" DRAFT	150 LTons
100-Ton Floating Crane		140'	70'	6' DRAFT	1410 LTons
250 TON CRANE	Assembled	over 73'	12'	13'6"	177/130 STons 7/
	Largest Pc, Tact. Disassembly 5/	47'7"/57.7 8/	12'	13'6"	110 STons
	Largest, Adm. Move 6/	47'7"	12'	8-4"	61 STons
140 TON CRANE	Assembled	40' (Approx) 4/	11'3"	13'-1"	81/61 STons 9/
	Largest of 3 pc Disassembly	33'	11'3"	9' -4" (Approx)	47 STons
Rough Terrain Toplift Loader		24'-2¼"	10'4"	8'5"	52 STons
Lancer Side Loader		31'4"	12'3"	11'5"	41 STons
D-8 Bulldozer (Operational)		20'-9"	12'-1"	8'9"	22 STons 19.7 LTons

1/ NAVSHIPS Pub 250-452 shows weight as 134,000 lbs (i.e., 59.8 L Tons).

2/ *Heavier designs of aluminum LCM8s have also been built.*

3/ The 3x15 configuration is most common in Navy use, but hardware for using fewer or more are shown in Navy publication, (e.g., 4x12, 5x12 or 3x5). Elements weight approximately 1.5 tons.

4/ Following are selected dimensions from manufacturer's brochure: length of truck on which crane is mounted 32'-10½"; overall length with 25' upper section of boom assembled, 73'7½". with upper 25' section folded back, 50-1"; *turning radius* 51'6".

5/ In this configuration, crane can be reassembled in 8 hrs. by an experienced crew of 6 ro 10 men.

6/ In this configuration, crane can be assembled in a minimum of 2-3 days if experienced crew of 6-10 men and lift equipment are available.

7/ 176.5 is weight of complete basic machine including 3 counterweights and 70' boom as shown in P&H brochure. Removing 3 counterweights reduces weight by 46.3 STons to 130 STons.

8/ The smaller figure is for the crane with boom base removed or raised. The larger figure includes the standard boom base in a horizontal position.

9/ 81 STons is weight of basic machine with hydraulic outrigger as shown in P&H brochure. The one-piece counterweight weighs 20 tons and is self removable.

TABLE 4

WORKSHEET FOR LIFTING CAPABILITIES OF SHIPBOARD EQUIPMENT

This table shows technical weight-lift capabilities only. It does not consider space and other factors discussed in later sections of this report, so does not represent final answers. Note, however, that a <u>no</u> answer is this table is final in the sense that the lift is not feasible.

Note: Capacities of Shipboard Cranes are customarily shown as not varying with boom reach. Capacities are usually shown in long tons, as in this table.

		HEAVY LIFT B.BULK SHIPS				BREAK BULK SHIPS[1/]						BARGE SHIPS							
		120 LT Boom		two [illegible] booms (married)		75 LT Boom		60 LT Boom		50 LT Boom		LASH[2/] without barge		LASH[2/] in or on barge		SEA-BEE[3/] without barge		SEA-BEE[3/] in or on barge	
	Weight	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable	deficit or excess	acceptable
LCU (1466 Class)	180LT	-60	No	+60	Yes	-105	No	-120	No	-130	No	+330	Yes	NC	NC	-	Yes	NC	NC
LCU (1610 Class)	165LT	-45	No	+75	Yes	- 90	No	-105	No	-115	No	+345	Yes	NC	NC	-	Yes	NC	NC
LCM-8 (Steel)	58LT	+62	Yes	-	-	+17	Yes	+2	Yes close	-8	No	+452	Yes	NC	NC	-	Yes	NC	NC
LCM-8 (Aluminum)	36LT	+84	Yes	-	-	+39	Yes	+24	Yes	+14	Yes	+474	Yes	NC	NC	-	Yes	NC	NC
LARC 60	87LT	+33	Yes	-	-	-12	No	-27	No	-37	No	+423	Yes	NC	NC	-	Yes	NC	NC
LACV-30	28LT	+92	Yes	-	-	+47	Yes	+32	Yes	+22	Yes	+482	Yes	NC	NC	-	Yes	NC	NC
Causeway 3 x 15 = 45 elements	61LT	+59	Yes	-	-	+14	Yes	-1	No close	-11	No	+449	Yes	NC	NC	-	Yes	NC	NC
Delong "B" Barge	800LT	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	800 [4/]	NC	NC	NC
LASH Barge	80LT	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	+372	Yes	NC	NC	-	Yes	NC	NC
SEA-BEE Barge	150LT	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	-	Yes	-	Yes
250-Ton Crane: Operational (less ctr.wts)	130LT	-10	No	-	Yes	-55	No	-70	No		No		NC		NC		Yes		Yes
250-Ton Crane: Largest pc of tactical disassembly	98LT	+22	Yes	-	-	-23	No	-38	No	-48	No		NC		NC		Yes		Yes
250-Ton Crane: Largest adm. move	55LT	+95	Yes	-	-	+20	Yes	+5	Yes	-5	No		NC		NC		Yes		Yes
140-Ton: Operational (less ctr.wts)	61LT	+59	Yes	-	-	+14	Yes	-1	No Close	-11	No		NC		NC		Yes		Yes
140-Ton: Largest of 3 pc disassembly	42LT	+78	Yes	-	-	+33	Yes	+18	Yes	+8	Yes		NC		NC		Yes		Yes
100-Ton Floating Crane	1410LT	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	+590	Yes	NC	NC

NOTE: NC denotes Not Considered; usually because of considerations shown previously.

1/ Preliminary assessment of Break Bulk Ships' gear indicates that few heavy lift booms are located in pairs, so as to provide married lift capability. Thus married falls are not considered in this category.

2/ Designed capacity of LASH Lift gear = 510 tons.

3/ Designed capacity of Elevator = 2000 tons.

4/ Studies of technical feasibility currently being made under Navy sponsorship.

TABLE 5

WORKSHEET FOR SPACE CONSIDERATIONS FOR LOTS EQUIPMENT ABOARD VARIOUS SHIP TYPES

THIS TABLE SHOWS SPACE CONSIDERATIONS ONLY. IT DOES NOT CONSIDER WEIGHT OR OTHER FACTORS DISCUSSED IN LATER SECTIONS OF THIS REPORT, SO DOES NOT REPRESENT FINAL ANSWERS.

SHIP TYPE / EQUIPMENT	HEAVY LIFT BREAKBULK SHIPS		TYPICAL BREAKBULK SHIPS		BARGESHIPS				RO/RO SHIPS		
					LASH		SEABEE		SEALIFT CLASS	MAINE CLASS	COMET
	Deck Space?	In Hatch?	Deck Space?	In Hatch?	Without Barge	in or on Barge	Without Barge	in or on Barge	Clearance thru Stern Port 7/	Clearance thru Stern Port 8/	Clearance thru Stern Port 9/
LCU 1466	YES (ON HATCH)	NO	UN-LIKELY	NO	NO	NC	YES 4/	NC	NC	NC	NC
LCU 1610	YES (ON HATCH)	NO	UN-LIKELY	NO	NO	NC	YES 4/	NC	NC	NC	NC
LCM-8 (STEEL)	YES	YES	YES	NO	YES 2/	NC	YES	NC	NC	NC	NC
LCM-8 (ALUMINUM)	YES	YES	YES	NO	YES 2/	NC	YES	NC	NC	NC	NC
LARC-60	YES	YES	YES	NO	NO 3/	NC	YES	NC	NO	NO	NO
LACV-30	YES	POSS-IBLY 1/	YES	NO	YES 3,5/	NC	YES	NC	NO	NO	NO
CAUSEWAY (3 ELEMENTS x 15)	YES	NO	YES	NO	UNDER STUDY 4/	NC	YES	NC	NC	NC	NC
"B" DELONG	NOT APPLI-CABLE	NOT APPLI-CABLE	NOT APPLI-CABLE	NOT APPLI-CABLE	NO	NO	YES 4/	NC	NC	NC	NC
LASH BARGE	YES	YES	YES	NO	YES	NO	NC	NC	NC	NC	NC
SEA-BEE BARGE	YES	NO	UN-LIKELY	NO	NO	NC	YES	NC	NC	NC	NC
250 TON CRANE — ASSEMBLED	YES	YES	YES	NO	NO	YES	YES	YES	YES	YES 9/	NO
250 TON CRANE — LARGEST PIECE, TACTICAL MOVE	YES	YES	YES	UN-LIKELY	YES	YES	YES	YES	YES	YES 9/	NO
250 TON CRANE — LARGEST PIECE, ADMIN. MOVE	YES	YES	YES	UN-LIKELY	YES	YES	YES	YES	YES	YES	YES
140 TON CRANE — ASSEMBLED	YES	YES	YES	NO	NO	YES	YES	YES	YES	YES 9/	NO (CLOSE)
140 TON CRANE — LARGEST OF THREE PIECE DISASSEMBLED	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES 9/	NO (CLOSE)

NOTE: NC DENOTES NOT CONSIDERED: USUALLY BECAUSE OF CONSIDERATIONS SHOWN PREVIOUSLY

1/ LARGEST HATCH ON TRANSCOLORADO AND TRANSCOLUMBIA, FOR EXAMPLE, 75' x 35'-4"; LACV-30 IS 76'-3" x 33'.

2/ REQUIRES SPECIAL LIFT BEAM AND MODIFICATION TO ELECTRONIC CONTROLS ABOARD SHIP. SEVERAL BEAMS AVAILABLE AND ALL C9 TYPE LASH SHIPS HAVE BEEN MODIFIED.

3/ THE NO ANSWER COULD BE CHANGED IF USE OF LIFT BEAM (SEE FOOTNOTE 2) WITH SPECIALLY FABRICATED SLINGS CAN BE ARRANGED. VERTICAL CLEARANCES ARE CLOSE.

4/ BEING INVESTIGATED IN NAVY PROJECT.

5/ CLEARANCES ARE CLOSE AND SMALL COUNTERWEIGHTING IS INDICATED. STUDY OF STRESSES ON LACV-30 IS RECOMMENDED.

6/ STERN PORT IS 18' x 18'.

7/ STERN PORT HAS DOOR 16' HIGH x 42' WIDE, RAMP HAS MINIMUM WIDTH OF 24'.

8/ COMET STERN PORT IS 17' 10½" WIDE BY 13' HIGH.

9/ TURNING RADIUS INSIDE SHIP MAY BE HINDRANCE.

Carrying Equipment on Containerships. Containerships are not included in the material discussed thus far. Most containerships having gantry cranes for self-unloading can lift only up to about 28 tons. The self-sustaining containerships with conventional type booms usually have a heavy-lift boom with a 50-or 60-ton capacity. For these ships, the appropriate columns of Table 4 for breakbulk ships apply.

For non-self-sustaining (NSS) containerships, a mobile crane that can move on deck will be used for discharging containers. A P&H Truck Crane of this type is part of the Table of Equipment of the Army's newly developed terminal service company (container). In addition, the Navy has under development the application of a mobile crane of similar design and capability for the crane-on-deck containership discharge concept. In addition to its primary use of unloading containers, it could also unload other LOTS equipment which might be deployed by a containership. (For most heavy loads different boom lengths and different crane riggings are required than for container unloading.)[1/]

A 250-ton crane is also part of the terminal service company (container). Its major LOTS roles are as a crane-on-barge for unloading containers from a ship, and unloading lighters at the shoreline.

The requirement for a long reach for moving containers— either across the deck of the ship or from a landing craft at a shoreline— results in choosing cranes that, at much shorter reaches, have high lifting capabilities. The change in lift capabilities with reach is summarized in Figure 4. The capacities were plotted from load-rating plates in pertinent manufacturer's brochures (P&H). The heavy loads require the use of heavy-duty boom tips rather than container-tips. A 50 or 60-foot boom is used for the region of the curve of interest for the heavy lifts. The cranes were assumed to operate with the boom over the rear of the carrier.

Table 6 shows the result of first approximation calculations of the capabilities of 140-ton cranes, singly or in tandem, to unload LOTS equipment from the deck of the non-self-sustaining containership under calm-sea conditions. The crane lift capabilities were assumed to be as shown in the lower curve of Figure 4. As shown in the sketch at Figure 5, the heavy lifts were assumed to take place with the crane positioned as close to the deck edge as feasible. It may be necessary to place beams under the outrigger pads to distribute the concentrated load.

Deployment of 250-Ton and 140-Ton Capacity Cranes

Deploying the heavy-lift mobile cranes presents problems because of their weight and size. Fully operational, the 250-ton P&H 6250 truck crane, complete with its three standard counterweights, a 70-foot boom and mast, its cables, and a hook block, weighs 177 short tons, according to the P&H descriptive circular. This configuration would have a length, with the boom in a near-horizontal position, of over 110 feet. It is too long and too heavy to transport in a fully operational configuration.

[1/] Changing booms does not require any lift equipment other than the crane itself. The crane presumably would be in the heavy lift configuration at first, then be changed to the container handling configuration by adding boom inserts, changing to a container tip, and re-rigging the lift blocks so that the load moves faster. Note that the boom sections would require space on the deck of the ship.

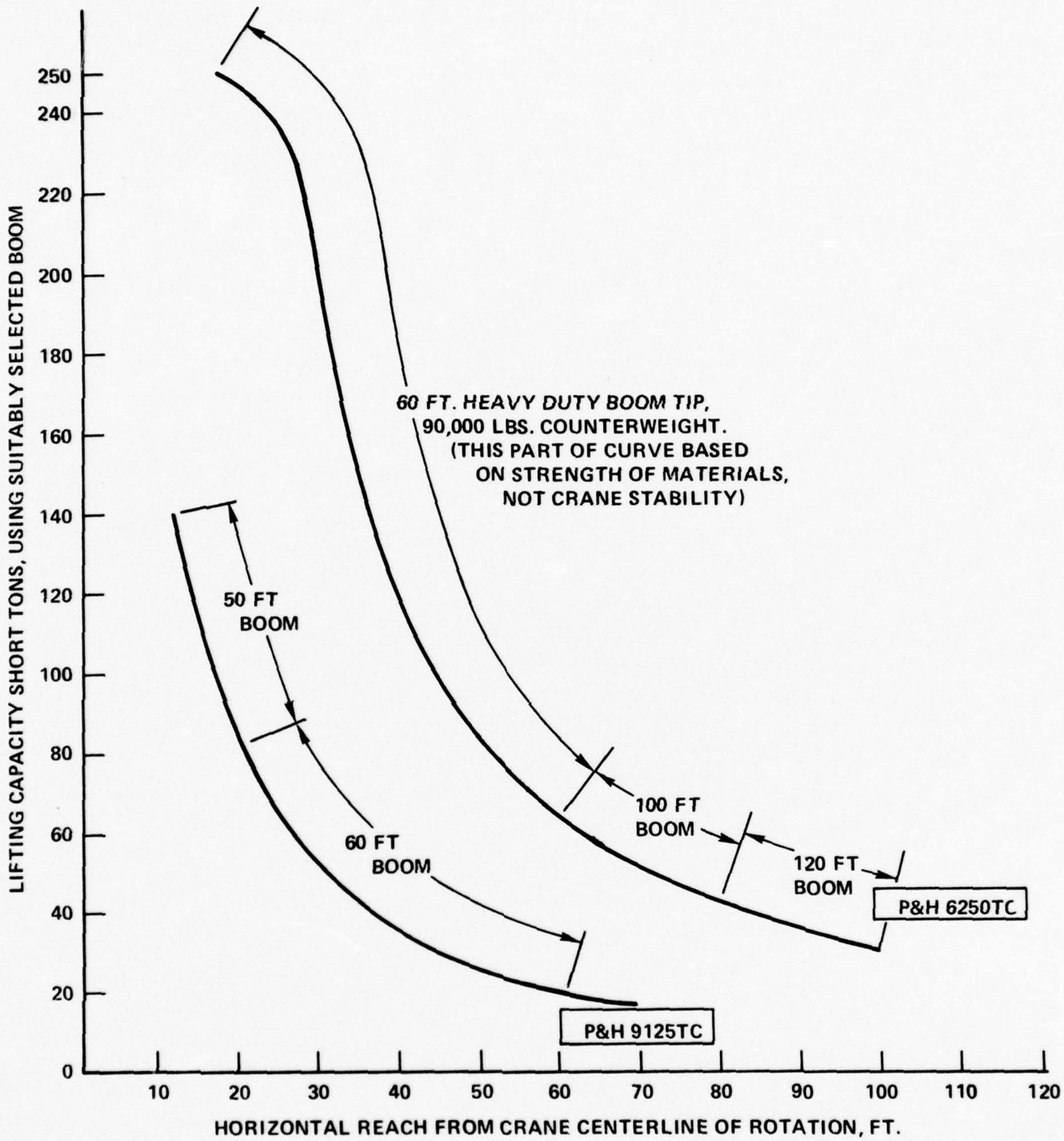


FIGURE 4. RELATION BETWEEN CRANE REACH AND LIFTING CAPACITY, FOR P&H TRUCK CRANES 6250TC and 9125TC.

Values are maximums for: selected lengths of boom; heaviest standard counterweights; operation over rear of carrier; use of mast; and for the 6250TC, use of auxiliary outriggers at rear (i.e., floats). Sources: P&H Brochure TX-538-CC1, page 7, for 6250TC. For 9125, Brochure 5M-874 DLC, Plate labelled PCSA Class 12=736, 62,000 lbs. counterweight.

TABLE 6

THEORETICAL CAPABILITIES OF ONE AND TWO 140-TON MOBILE CRANES OPERATING FROM DECK OF NON-SELF-SUSTAINING CONTAINERSHIP TO LOAD OR UNLOAD LOTS EQUIPMENT

(TABLE ASSUMES SHIP MOTION TO BE NEGLIGIBLY SMALL)

		140-TON CRANE				TWO 140-TON CRANES IN TANDEM		
		required reach, including 11, ℄ of crane to deck edge	crane capability at given radius, STons	Deficit (-) or Excess (+) capacity, STons	Is weight acceptable for test?	crane capability in tandem	Deficit (-) or Excess (+) capacity, STons	Is weight acceptable for test?
	LCU (1466 Class)	32'	46	-156	No	92	-110	No
	LCU (1610 Class)	30½	50	-135	No	100	-85	No
	LCM-8 (Steel)	24 1/	70	+5	Yes 1/ (Marginal)	not	considered	
	LCM-8 (Aluminum)	25	65	+34	Yes	not	considered	
	LARC 60	28	55	-42	No	110	13	Yes
	LACV-30	32	48	+17	Yes	not	considered	
	Causeway 3x15 = 45 elements	20' 2/	85	+17	Yes	not	considered	
	DeLong "B" Barge		not				considered	
	LASH Barge		not				considered	
	SEA-BEE Barge		not				considered	
[illegible] TON CRANE	Operational w/o cntr. weights	31 3/	49	-81	No	98	[illegible]	[illegible]
	Tactical Disassembly			-61	No		-12	No
	Administrative Disassembly			-12	Yes(Marginal) 1/		+37	Yes
140 TON CRANE	Operational	31 3/	49	-46/-26 4/	No	98	+17/+37 4/	Yes
	Tactical Disassembly			+2	Yes (Marginal)		—	—

1/ Operation becomes possible if fender distance is decreased from 4' to 2'.

2/ Launched edge first. Suspended from eyes on one side of causeway. See Figure in Appendix A.

3/ Half width of the crane being lifted is only six feet, but extra clearance must be allowed to permit it to be centered in the landing craft or barge that moves it ashore. Total reach requirement estimated to be 31' for the 140-ton crane (horizonal distance from pivot of boom foot to the line supporting the load).

4/ Operational configuration; *with and without counterweight(s)*.

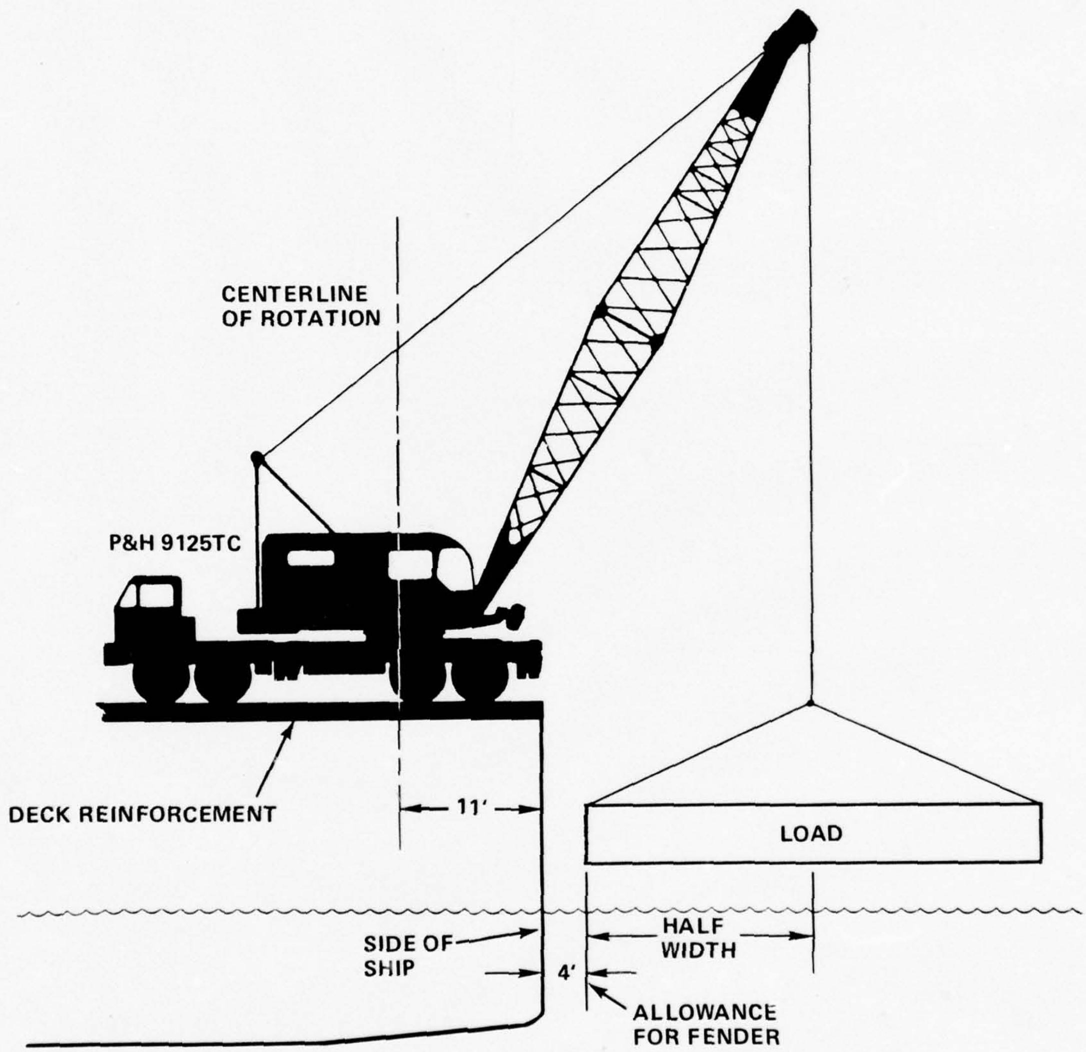


FIGURE 5. DIMENSIONS USED IN FINDING REQUIRED REACH FOR CRANE-ON-DECK OPERATIONS

Assembled 250-Ton Crane Without Counterweights. Various degrees of disassembly are possible. One is a normal stage in the commercial use of the crane and can be accomplished by a crew experienced in crane operations. It is removal of the three counterweights (total weight 46 tons) and the 30-foot boom tip. Assuming the boom tip and the counterweights are suitably located, no outside equipment is needed for the crane to be reassembled. It is still, in a sense, in an operating configuration; without counterweights the crane weighs 130 tons. With the boom tip removed the crane weighs 127 tons and is about 70 feet long. Limited transport in this configuration may be feasible.

Disassembly of 250-Ton Crane for Tactical Movement. Still further disassembly requires use of lift equipment for removing the lower boom section. The "minimum breakdown for deployment shipment," or disassembly for tactical movement, was used for the OSDOC II tests. In this configuration the heaviest piece is the chassis with turret (also called the "upper"). The weight for this configuration is shown as 110 short tons in the ATSP-CTD-DS Fact Sheet of 10 January 1975 and is used in this study.[2/] It is not within the tandem lift capability of two 140-ton cranes-on-deck.

Disassembly of 250-Ton Crane for Administrative Type Movements. Overseas commercial shipment of the P&H 6250 is accomplished in a still further disassembled state. In particular, the upper is separate from the carrier. The heaviest piece is the carrier, shown in the P&H brochure at 61 short tons, and next is the machine upper, shown as 47 tons. The assembly time from this configuration is given in the fact sheet referred to above as a minimum of two to three days providing good lift equipment and an experienced crew of 6 to 10 men are available. The mating of the upper with the carrier requires particular skills and is not a routine operation in commercial practice.

Assembled 140-Ton Crane. In the crane-on-deck role, one employment concept for the 140-ton crane is to put it aboard the NSS containership at a port of debarkation and leave it aboard after the containers (and any LOTS equipment carried aboard) are discharged. Other concepts of crane use envision removing the crane from the ship and its transfer to another ship for discharge operations.

The assembled crane with a 25-foot boom lower section in a horizontal position is approximately 40 feet long and weighs 81 short tons (or 61 short tons with the single counterweight removed). The counterweight is removable without using outside lifting equipment.

Tactical Movement Configuration for 140-Ton Crane. Sufficient reduction in weight and size for overseas shipping can be obtained without the need for disassembly of the crane upper from the carrier. It can be disassembled into three main components: the carrier with upper; the counterweight; and the boom sections. The first is the heaviest and weighs 47 tons.[3/] It is 32 ft 10½ in. long.

[2/] Information from the P&H brochure giving details of the 6250-TC Crane could be used to show that the total weight should be slightly higher. For example, the total for carrier, machine upper with gantry, operations module, and cables is 112.6 tons.

[3/] This is the weight of the machine with the following removed: counterweight; complete boom; complete outriggers; rear frame section; hoist and boom hoist ropes. (Reference— crane axle loading sheet of P&H brochure.)

Assembly time has been estimated as six to seven hours, with 6 to 10 men. With only counterweights, rear outriggers, and boom tip removed, assembly time can be reduced to about two hours, with the weight of the largest assembly increased only a few tons.

TEST SUITABILITY CRITERIA

In deciding which ship-equipment combinations would be appropriate candidates for pretest, several factors relevant to the test situation must be considered. In order to permit use of a tabular format shown later, the specific criteria are put into the form of questions that can usually be answered "yes" or "no". They are:

a. Usable Combination? Is the information that the pretest will provide pertinent to ships and equipment that are sufficiently important to the LOTS mission and/or the main test concepts to warrant the expense of the pretest? The intent here is to eliminate patently unjustified pretests of equipment-ship combinations and to encompass all potentially usable deployment means in order that sufficient data will be available to optimize the combinations in subsequent analysis and evaluation.

b. Available in Time Frame? Is the equipment scheduled to be available in time to be pretested?

c. Preparations? Could any required engineering studies or necessary equipment modifications be completed in time (and within reasonable costs) for the pretest to go forward?

d. Non-Redundant?[4/] Is it desirable to make the test, taking into account whether a similar test has already been made in the past, whether there is a reasonable amount of military experience in the area, and whether other similar, perhaps more difficult, pretests are already contemplated? Note that this query requires particularly careful consideration since part of the purpose of the pretest is to provide viable alternative ways of deployment, to account for the possibility that a particular ship type may not be quickly available in an emergency.

Answers to the above are based on both factual information and judgment, as contrasted to the criteria for weight and space which are basically factual. There can be borderline answers. In addition there are a few answers (for example, to the query on non-redundancy) which may depend on the test sequence in which the ship-equipment combination is considered.

Specific "yes" or "no" entries to the above questions are found in Tables 7,8, and 9.

[4/] In order to make the yes or no answers to this question consistent with the answers to the other questions, it had to be put into the unusual form shown: The question does not ask the straightforward "Is the test redundant?", which would have resulted in a series of No's. Rather, the question is asked with an additional negative layer, "Is the test non redundant?" to which a yes answer, like a yes answer to the other questions, means a favorable answer with respect to justifying a test.

TABLE 7. SUMMARY OF APPLICATION OF CRITERIA FOR CANDIDATE EQUIPMENT-SHIP COMBINATIONS--BREAKBULK

NC = Not Considered.

	Heavy Lift BB ship with single or paired 120T Booms		BREAKBULK SHIPS																				
			70-Ton Boom							60-Ton Boom							50-Ton Boom						
	Weight and space Ok?	Pre-Test Non-Redundant?	Weight	Space	Pre-Test Non-Redundant?	Available on time?	Preparations?	Usable Combinations?	Cost Acceptable?	Weight?	Space	Pre-Test Non-Redundant?	Available on Time?	Preparations?	Usable Combination?	Cost Acceptable?	Weight	Space	Pre-Test Non-Redundant?	Available on Time?	Preparations?	Usable Combination?	Cost Acceptable?
LCU (1466 Class)	Yes	Yes	No	NC						No	NC						No	NC					
LCU (1610 Class)	Yes	Yes	No	NC						No	NC						No	NC					
LCM-8 (Steel)	Yes	No	Yes	vari-able	Yes	Yes	Yes	Yes	Yes	Yes (mar-gin-al)	vari-able	Yes	Yes	Yes	Yes	Yes	No						
LCM-8 (Aluminum)	Yes	No	Yes	vari-able	Yes	Yes	Yes	mar-gin-al	Yes	Yes	vari-able	Yes	Yes	Yes	mar-gin-al	Yes	Yes	vari-able	Yes	Yes	Yes	mar-gin-al	Yes
LARC 60	Yes	Yes	No	NC						No	NC						No	NC					
LACV-30	Yes	No	Yes	vari-able	Yes	Yes	Yes	Yes	Yes	Yes	vari-able	Yes	Yes	Yes	Yes	Yes	Yes	vari-able	Yes	Yes	Yes	Yes	Yes
Causeway 3 x 15 = 45 elements	Yes	Yes	Yes	un-like-ly	Yes	Yes	Yes	Yes	Yes	No (mar-gin-al)	un-likely	Yes	Yes	Yes	Yes	Yes	No	NC					
DeLong "B" Barge	No	NC	No	NC						No	NC						No	NC					
LASH Barge	Yes	No	No	NC						No	NC						No	NC					
SEA-BEE Barge	Yes	No	No	NC						No	NC						No	NC					
250 TON CRANE: Operational	Yes	Yes	No	NC						No	NC						No	NC					
250 TON CRANE: Largest pc, Tact. Dis-assembly	Yes	No	No	NC						No	NC						No	NC					
250 TON CRANE: Largest pc, aft. move	Yes	No	Yes	Yes	Yes	Yes	Yes	mar-gin-al	Yes	Yes	Yes	Yes	Yes	Yes	mar-gin-al	Yes	No	NC					
140 TON CRANE: Operational	Yes	No	No	NC						No	NC						No	NC					
140 TON CRANE: Largest of 3pc disassembly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

BEST AVAILABLE COPY

TABLE 8

SUMMARY OF APPLICATION OF CRITERIA FOR CANDIDATE EQUIPMENT-SHIP COMBINATIONS--NSS CONTAINERSHIPS

		NON-SELF-SUSTAINING CONTAINERSHIPS														
		140-Ton Crane							Two 140-Ton Cranes							
		Weight?	Space	Pre-Test Non-Redundant?	Available on Time?	Preparations?	Usable Combination?	Cost Acceptable?	Weight	Space	Pre-Test Non-Redundant?	Available on Time?	Preparations?	Usable Combination?	Cost Acceptable?	
LCU (1466 Class)		No	NC						No	NC						
LCU (1610 Class)		No	NC						No	NC						
LCM-8 (Steel)		Yes (marginal)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1/
LCM-8 (Aluminum)		Yes	Yes	No	Yes	Yes	Yes	Yes	not necessary to test if steel version can be lifted							
LARC 60		No	NC						Yes	Yes	Marg.	Yes	Yes	Yes	Yes	
LACV-30		Yes	Yes	Yes	Yes	Yes	Yes	Yes	not necessary to test							
Causeway/ 3 x 15 = 45 elements		Yes (marginal)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1/
DeLong "B" Barge LASH Barge SEA-BEE Barge			NC						NC							
250 TON CRANE	Operational	No	NC						NC							
	Largest of 3pc disassembly	No	NC						No (marginal)	Yes	Yes	Yes	Yes	Yes	Yes	
	Largest pc, adm. move	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Marg.	Yes	Yes	Yes	Yes	1/
140 TON CRANE	Operational	No	NC						Yes	Yes	No	Yes	Yes	Yes	Yes	
	Largest of 3pc disassembly	Yes (marg)	Yes	Yes	Yes	Yes	Yes	Yes	Yes marginal	Yes	Yes (Marg.)	Yes	Yes	Yes	Yes	1/

Legend: NC = Not Considered.

1/ Test not necessary if one crane can perform lift.

TABLE 9

SUMMARY OF APPLICATION FOR CANDIDATE EQUIPMENT-SHIP COMBINATIONS--BARGESHIPS

	BARGESHIPS													
	LASH							SEABEE						
	Weight	Space	Pre-Test Non-Redundant?	Available on time?	Preparations?	Usable Combinations?	Cost Acceptable?	Weight?	Space	Pre-Test Non-Redundant?	Available on Time?	Preparations?	Usable Combination?	Cost Acceptable?
LCU (1466 Class)	Yes	No	← NC →					Yes	Yes	Yes	Yes	Yes	Yes	Yes
LCU (1610 Class)	Yes	No	← NC →					Yes	Yes	Yes	Yes	Yes	Yes	Yes
LCM-8 (Steel)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LCM-8 (Aluminum)	Yes	Yes	No	Yes	Yes	Yes (Marg)	Yes	Yes	Yes	No	← NC →			
LARC 60	Yes	No	← NC →					Yes	Yes	Yes	Yes	Yes	Yes	Yes
LACV-30	Yes	Yes	Yes	Yes	Marg.	Marg.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Causeway 3 x 15 = 45 elements	Yes	under study	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DeLong "B" Barge	No	← NC →						Yes	Yes	Yes	Yes	Yes	Yes	Yes
LASH Barge	Yes	← NC →						Yes	Yes	No	← NC →			
SEABEE BARGE	Yes	No	← NC →					Yes	Yes	No	← NC →			
[illegible]-Ton Capacity Floating Crane	No	← NC →						Yes	Yes	No	← NC →			
250 TON CRANE — Operational	Yes	No	← NC →					Yes	No	← NC →				
250 TON CRANE — Largest pc, Tact. Dis-assembly	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
250 TON CRANE — Largest pc, adm. move	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
140 TON CRANE — Operational	Yes	No	← NC →					Yes	No	← NC →				
140 TON CRANE — Largest of 3pc disassembly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Legend: NC = Not Considered.

C. SHIPS TO BE EMPLOYED

GENERAL

The criteria for LOTS main and pretest ship selections have their origin in the two primary roles in which it is anticipated that merchant dry cargo ships are to be employed, namely deployment support and sustained cargo throughput. Consideration of each of these functions is necessary in ship selections because of the varied capabilities needed to expeditiously transport, establish, and subsequently conduct a realistic LOTS type operation. The broadest criteria that can be applied in evaluating both deployment and throughput support relates fundamentally to:

- Equipment/cargo weights and sizes
- Ship stowage spaces and accesses
- Time as a function of operational responsiveness and ship speed
- Ship availability for testing and contingency operations.

In addition to such broad criteria for ship selections, DDR&E (T&E) tasked ORI to consider for testing each of the basic ship types (breakbulk, container, RO/RO, and bargeship). This, in turn, required that ship selection be as representative as possible within each type in order for the test to be representative. Further, the LOTS test definition addressed the subject of ship selection and the importance of validating deployment capabilities of ships considered "theoretically capable" as being one of the most important facets of the testing program.

The approach to ship selection is multi-sided since it is influenced by economics, ship availability, and test requirements. In a "realistic" situation under either mobilization or non-mobilization with implementation of the Sealift Readiness Program (SRP), access to preferred or representative ships and ship types would be easier than will be the case for the LOTS test. Under peacetime conditions military ship requirements are in competition with routine business and economic interests. The most representative ship may not be available. In the case of the breakbulk ships especially, Military Sealift Command (MSC) assets will be used whenever possible, first, to reduce test costs and, secondly, because of their better availability than other ships.[1/]

For test and evaluation purposes pretest criteria are also influenced by the desirability of analyzing the "most demanding" situation as opposed to a preferred (easier) case. The most complete range of data generated will result from examining the load limitations, operational constraints, and necessary modifications for deployments that might require use of ships which have only marginal support capabilities. Thus, the general approach to ship selection within the types specified for the test program requires striking a qualitative balance among the factors of ship typicality, operational realities and data requirements necessary for a most comprehensive deployment analysis. For example, numerical representativeness was less compelling in selection of the heavy-lift breakbulk and SEABEE ships than were operational considerations. Both unique requirements and unique capabilities were overriding in their inclusion.

There are only two types of bargeships, SEABEE and LASH. Since all SEABEES are the same basic design and there are only two basic LASH types, the selection criteria for these ships are less extensive than those required for containerships or breakbulk ships.

The most significant criteria in selection of a LASH for use in the pretests is compatibility with the LCM8 lift beam. Currently, only the C981 type LASH ships have been modified to accommodate the LCM8 lift beam, a feature essential to LOTS system equipment deployment and its testing. If certain modifications to the lighter gantry crane are made the C881 LASH could also be used.

RO/RO ship characteristics and types available for the LOTS test were not evaluated in detail (see Appendix A). Due to the lack of an existing prototype "marriage" ramp (for off-shore RO/RO operations), and because it was an "optional" test ship in the original DDR&E test program guidelines, the RO/RO ship pretest will probably not be practical during the FY 76-7T timeframe. Consideration of a FY 77 RO/RO evaluation will depend upon the results of other ship pretests and the availability of a suitable ramp.

[1/] For the most part, MSC breakbulk ships consist of CHALLENGER class vessels built in the early 1960s. These have slightly greater boom capacities and more stowage space for heavy lifts than 60 percent of the breakbulk ships of the merchant fleet. Therefore, these ships are preferred for deployment, but are slightly less representative of fleet capabilities.

CRITERIA FOR THROUGHPUT OPERATIONS

Throughput (or resupply support) is characterized by sustained ship-to-shore operations as opposed to the surge and often specialized requirements characterized by a deployment. Thus, the basic approach was to identify the most "typical" or representative dry cargo ship, particularly a containership, that normally would be involved in a LOTS situation. If the identified typical ship can be chartered, it will minimize the need to extrapolate data collected during the test.

GENERAL CRITERIA FOR DEPLOYMENT

Deployment requirements to support a LOTS operation are primarily characterized by the necessity for a ship to have sufficient lifting capacity and stowage space to accommodate certain outsized equipment selected for loading. While this equipment for the most part is larger and heavier than some of the heaviest combat material, it is not practical or necessary for pretest purposes to physically load and off-load all material and equipment of a complete LOTS system aboard each ship type. To assist in evaluating ship capabilities, only the largest and heaviest equipment which appears to be deployable on the basic type ship will be test loaded.

In structuring the pretests, the apparent compatibility of certain test lifts and ships, and the desire to selectively maximize equipment types (by function) on each ship type resulted in equipment mixes aboard some ships which provide the nucleus of a LOTS system capability (although not that required for a full LOTS system of sufficient capacity to support major force throughput requirements or ship turnaround schedules). While it is not intended that the pretests employ combat loads or loading combinations of LOTS system equipment, the flexibility to "spread-load" mission-essential items may ultimately be a significant factor in the overall deployment analysis.

Table 10 provides a general guideline to some of the deployment load and off-load criteria used as the basis for pretest design. While it does not attempt to include all equipment or LOTS support requirements, it does provide the basic criteria for examining ship capabilities with respect to the most critical lift requirements (weight and size).

While boom capacity limits are commonly used as a measure of capability, certain ship dimensional considerations are also important. A second part of the evaluation of deployment potential involved the ability to stow the equipment somewhere aboard ship and necessitated an examination of hatch square sizes (at the hold serviced by the jumbo boom) and hold and below deck clearances. Included in this analysis was the factor of equipment load integrity. A ship capable of accommodating LOTS heavy equipment and landing craft with a minimum requirement for disassembly and/or modification was judged preferable to one which requires extensive equipment disassembly and/or special modifications of ship or equipment for loading. Even though one ship may be slightly slower than another, the time and effort saved by avoidance of equipment reassembly would be of greater significance and would result in earlier establishment of a LOTS capability in the objective area than one which arrives sooner but takes more time and effort before the system elements it deploys are ready for operation.

TABLE 10

GENERAL CRITERIA USED FOR DEVELOPMENT OF SHIP LOAD/OFF-LOAD PRETESTS
AND SUBSEQUENT EVALUATION OF CAPABILITIES

	PRIMARY CHARACTERISTICS INFLUENCING CRITERIA			LOTS SYSTEM FUNCTION(S)		
EQUIPMENT	WEIGHT (LTONS)	MINIMUM BOOM REQUIREMENT FOR LIFTING	OTHER CONSTRAINING FEATURES	SHORESIDE LOADING UNLOADING	LIGHTERAGE	SHIP UNLOADING
140-ton Crane (tactical disassembly)	42	50	L=33';H=13'1"	X		X
Toplift Loader	46.4	50	None	X		
250-ton Crane (tactical disassembly)	54.4	60	L=47'7"	X		X
LCM8	57.8	60	L=73'6";W=21'		X	
3 x 15 Causeway Assembly	60.3	70	L=90';W=21'3"	X	X	
250-ton Crane (tactical Disassembly)	98.2	120	L=47'7";H=13'6"	X		X
LCU	180	240	L=119';W=34';H=17'9"		X	
DeLong "B" Barge	650	N/A	L=150';W=60'			X

HEAVY-LIFT AND CONVENTIONAL BREAKBULK SHIP SELECTION CRITERIA

The criteria for determining the most suitable breakbulk ships to support a LOTS system deployment places primary emphasis on the capacity of the ship to load and unload the larger items of LOTS equipment. Thus, two major capabilities of the breakbulk type ship are of interest, boom capacities and hatch sizes. Because of their gross size and weights, the most demanding aspects of LOTS system deployment centers around the loading of LCUs, the 250-ton and 140-ton cranes, barges and causeways, and LCM8s; and their discharge in an off-shore environment.

Basically two types of breakbulk ships were considered for the pre-tests, a conventional breakbulk ship and the heavy-lift breakbulk ship. The heavy-lift breakbulk ship as described in this report includes all breakbulk ships having a boom or boom-marriage lift capability in excess of 80 long tons.[2/]

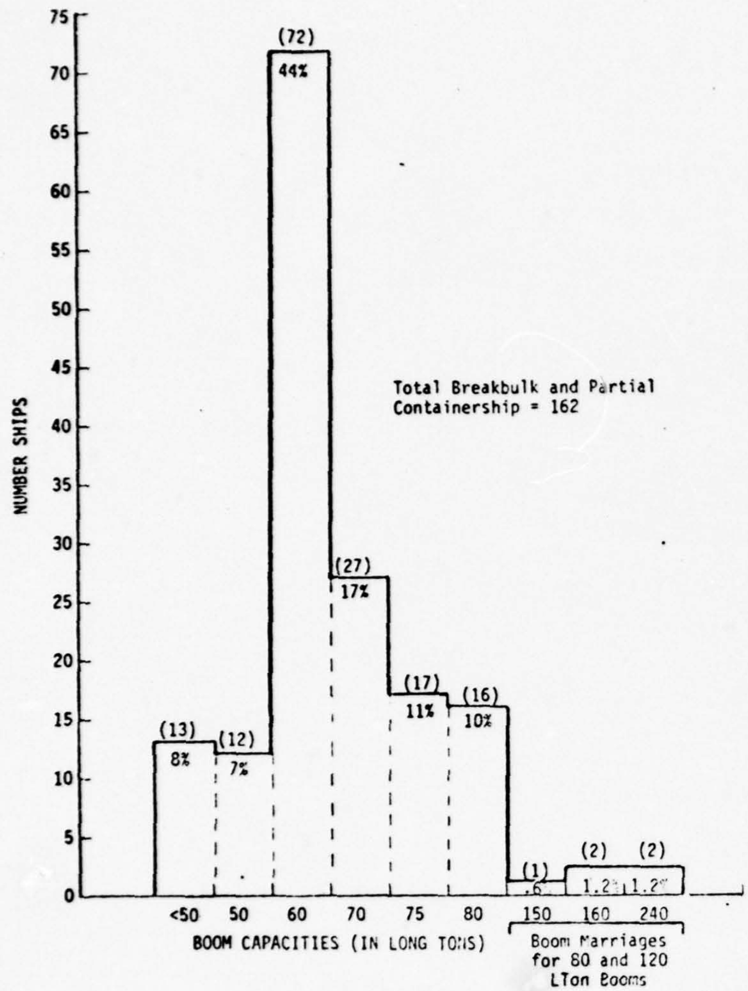
The heaviest lifts considered feasible for breakbulk type ships are an LCU (185 short tons), the tactically disassembled (three major components) 250-ton crane (the largest section weighing 110 short tons), the LARC-LX (97 short tons), an LCM8 (deployment weight of 65 short tons), causeway sections (67.5 short tons), a 250-ton crane administratively disassembled (the largest section weighing 61 short tons), and a toplift loader (52 short tons). Any breakbulk ship not capable of self-loading a toplift loader was considered marginal (see Figure 6). The actual load to be pretested is subject to the boom capacities of the ships selected. Table 10 gives the boom capacity required to lift each equipment item and the LOTS system components within range of each boom capacity level.

Breakbulk ships which have at least a 61-short ton boom capacity (55.5 long tons) appear to have the potential to deploy a minimal LOTS throughput capability. Such a capability consists of ship-to-shore lighterage[3/], the means to off-load and/or transfer the container to ground transportation, and the ground transportation for beach clearance (not considered a problem since it is all lighter and smaller than the LOTS equipment).

A second major consideration is the size of the ship's hatch squares. Only a limited amount of equipment can be deck-loaded, yet because of salt water and weather exposure, deck-loading is not a preferred method of transporting heavy equipment. Because of the sizes of equipment, hatch square dimensions were reviewed to determine if equipment could be hold-loaded. Overhead clearance problems can be overcome by loading on a hatch square and leaving the hatch square above either completely or partially open. This procedure reduces the availability of loading space on the level above, but it is a necessary trade-off if outsized LOTS equipment is to be deployed in conventional breakbulk ships.

[2/] At one time it was traditional to refer to any boom in excess of a 20 to 30-ton capacity as a heavy-lift boom, but this definition is not considered appropriate in terms of today's ship capabilities and lift requirements.

[3/] While a LACV-30 could provide lighterage for container throughput operations, it cannot serve as lighterage to unload the MHE required for container throughput operations ashore, such as the frontloader. Thus, an LCM8 is needed to off-load LOTS equipment too heavy or outsized for the LACV-30.



Maximum Capacity	No. Ships With this Capacity	MERFLEET Representation	
25-ton	3	1.9%	
30-ton	5	3.1%	
35-ton	5	3.1%	
50-ton	12	7.4%	
60-ton	72	44.4%	LOTS Deployment Capable Ships
70-ton	27	16.7%	
75-ton	17	10.5%	
80-ton	16	9.9%	
150-ton	1	0.6%	
160-ton	2	1.2%	
240-ton*	2	1.2%	

* Does not include one MSC RO/RO ship with this boom capacity.

FIGURE 6. MAXIMUM BOOM CAPABILITIES U. S. MERCHANT FLEET

The criteria for evaluating hatch square sizes necessarily centered around LOTS crane requirements (48-foot and 38-foot lengths). Hatches less than 30 feet long were considered unusable for deployment of a LOTS system (nearly all are greater). Equipment widths did not present a problem for hold-type cargo (i.e., container handling equipment) since the widest piece of equipment is the sideloader (12' 3") and nearly all hatch squares are at least 16 feet wide.

CONTAINERSHIP CRITERIA

For the deployment-oriented pretests, container cell size is secondary in the sense that container operations are not a major area of evaluation.[4/] The major consideration is the ship's deck configuration. Unobstructed deck space is a major factor in designing and evaluating the LOTS 140-ton crane loading and unloading tests.

The main test concepts outlined in the ORI LOTS feasibility and definition study indicated a requirement for a ship container capacity of approximately 450-600 containers in addition to the capability to transport and operate cranes on its deck. Because of the limited number of service-owned cranes to support both shoreside and shipboard operations during the test timeframe, it is desirable that the location of the superstructure not separate the cargo holds loaded with the ship's 450-600 containers.[5/] Because of the emerging trend toward larger containers, it is also desirable that the ship have a minimal capability to accommodate 40-foot containers (deck loading acceptable). Accordingly, the ship selected for pretesting should be of a similar design if deployment pretests are to have maximum application in the main test.

Other characteristics such as ship speed and its availability under the SRP are important. To the extent that the ship used for pretesting is accurately representative, the overall deployment analysis, which will involve extrapolation of field test data and calculations of realistic ship availability, will be greatly facilitated.

One major alternative concerning container capacity may also have to be considered. In the event acquisition of a more suitable ship or sufficient test container is cost-prohibitive, a 300-container capacity ship could be substituted—a significantly less desirable substitute, but one which circumstances might dictate.

HEAVY-LIFT AND CONVENTIONAL BREAKBULK SHIP SELECTIONS

Breakbulk and heavy-lift breakbulk ship characteristics were compared to evaluate suitability and availability of each (see Appendix A). Two ships, the TRANSCOLORADO and TRANSCOLUMBIA, are almost ideally suited for deployment support of LOTS systems equipment. They have the capability to load and unload LCUs and have hatch sizes with sufficient length and width to permit stowing

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[4/] Some integrated container handling tests are envisioned in the containership pretest to verify LACV-30 load options and ancillary container handling equipment and impact attenuation techniques.

[5/] Normally, a crane would be positioned aft of the superstructure, if required, to unload those holds.

outsized equipment below decks, such as a 250-ton crane (in tactical disassembled configuration). While three other heavy-lift breakbulk ships have the capability to load heavy-lifts (less LCUs), they are constrained by hatch squares (40' x 27') too small for hold-loading of other LOTS system equipment.

As shown in Figure 6 almost 85 percent of the breakbulk ships in the U. S. merchant fleet have a 60-ton or greater boom capacity. Also, it appears feasible, subject to LCM8/crane load test[6/], that a 60-ton boom breakbulk ship can deploy and off-load a nucleus LOTS capability. Subsequently, a 60-ton boom ship represents the most demanding pretest case and would provide for verification of capability applicable to the majority of the breakbulk fleet.

As indicated in Table 11, the 22 C41 type ships, while less preferable from an operational standpoint, meet the optimum test criteria based on minimum boom capacity and are the "most demanding" type ships. Unfortunately, there are no C41 type ships in the MSC controlled fleet. Use of MSC assets provides for a greater assurance of availability for testing, and procurement at substantially less cost than straight commercial charters. For this reason the 70-ton boom ships (second test preference ranking) are recommended for the LOTS pretest. The additional 10 tons of boom capacity will not have a major impact on deployment evaluation.

CONTAINERSHIP SELECTION

In selecting an appropriate containership, overall cargo and operating characteristics were compared to evaluate ship suitability and availability for LOTS main and pretests. (See Appendix A, Ship Suitability and Availability, for detailed tables and characteristics.) In the U. S. merchant fleet there are 91 NSS container vessels of 22 different hull types. For pretesting, this list can be slightly expanded by adding 16 self-sustaining containerships of five different hull designs which are an option if no suitable NSS containerships are available.

Approximately 63 percent of the NSS containerships (57 ships) are located or have ports-of-call on the East Coast. Of these, about half (33) are designed to accommodate 20-foot containers, while most of the remainder accommodate 35-foot containers.

Based on the criteria established, containerships were compared in Appendix A to determine the preferred containership (in this case, the most representative ship type) and alternatives (ships not fitting the basic criteria established above, but ones which could be used as a substitute). Table 12 lists these ships in their order of preference. The relevant differences between the number one and two preferences were minimal except that the C685 is not committed under the SRP while the C573 is. Because the C685 is faster, slightly larger, and has a 70-ton boom for accommodating other types of cargo (such as vehicles), its preference rating was slightly higher than the C573.

One other major factor in ship selection is East Coast availability. Diversion of a West Coast ship for testing would probably result in excessive costs, unless that ship is available in conjunction with scheduled yard work at an East Coast facility.

Detailed pretest descriptions and the rationale for their development are contained in Section D which follows.

6/ See Section D under "General" for further discussion of this test.

TABLE 11

PREFERRED CONVENTIONAL BREAKBULK SHIPS* FOR
LOTS SYSTEM DEPLOYMENT SUPPORT

Operational Preference	Test Preference	Hull Type	No. Hulls Available	Boom Capacity	Speed	Ownership
1	8	C466	10	80	20	Lykes Bros.
2	7	C460	6	75	21	Moore-McCormack
3	3	C464**	7	70	21.8	Prudential-Grace
4	2	C457**	11	70	21	U. S. Lines
5	6	C333	6	75	18	Moore-McCormack
6	5	C376	5	75	18.6	Delta
7	4	C4A1&C	4	70	17	James River Transport Mohawk, and Central-Gulf
8	1	C41	22	60	20	Waterman, Pac. Far East Lines, States Steamship Co., etc.

* Does not include 22 additional ships of five different hull types ranked below the C41.

** MSC charter ships included in this group.

TABLE 12

PREFERRED AND ALTERNATIVE
LOTS TEST CONTAINERSHIPS

Preferred Containerships

Hull Type	No. Ships with This Hull Type	No. Ships This Hull Type-East Coast	Twenty-Foot Container Capacity	Speed	Owner/Operator
NON-SELF-SUSTAINING					
C685	8	4	1,100	22.6	Farrell
C573	5	5	1,076	20	AEL
C61W	8	8	1,009	20	U.S.L.
C768	8	8	1,258	22.5	U.S.L.
		(Total 25)			
SELF-SUSTAINING					
None					

Alternative Containerships

really?

Hull Type	No. Ships with This Hull Type	No. Ships This Hull Type-East Coast	Container Capacity and Size	Speed	Owner/Operator
NON-SELF-SUSTAINING					
SL-7	8	4	1,096-35'	33	SL
C788	2	2	759-35'	23	SL
SL-18	2	2	759-35'	23	SL
C4-J	4	4	609-35'	17	SL
C4J1	2	2	622-35'	17	SL
EXC4	4	4	481-40'	17	PRMSA & SL
		(Total 18)			
SELF-SUSTAINING					
C4JC	3	3	602-35'	17	SL
T3J	4	4	476-35'	15.5	SL
		(Total 7)			

D. DESCRIPTION OF SHIP PRETESTS FOR LOTS SYSTEM DEPLOYMENT

GENERAL

Ship pretests have been designed to provide the means for verification of capabilities and, by extrapolation of the data collected, to serve as a basis for evaluation of alternatives in LOTS system deployment analysis. The pretests will verify certain loading and unloading capabilities not previously demonstrated but required for ships to support the deployment of the largest and heaviest LOTS system equipment. The pretests are designed to examine a broad range of alternative methods of deployment rather than a few limited options in order that optimized loads can be developed on a more empirical basis. They will also provide a basis from which to extrapolate data, first, on times to load and unload equipment and, second, on potential material, manpower, and other resource requirements.

After selection of ship types for pretesting, weight-critical equipment or equipment having special stowage considerations (i.e., shoring and chocking) was assigned to each ship to be test loaded. To determine if some mission capability could be embarked and still keep the total amount of equipment to a minimum, an order of priority for testing was established based on several factors including each equipment item's mission-essential relationship to a LOTS operation. For example, if a ship's boom capacity precluded loading more than 60 long tons, then an attempt was made to identify at least one item of lighterage, one crane, and a causeway section or a barge (as appropriate) that was within the lift capability. This appears possible since within each of these equipment categories there are options— such as the example illustrated in Table 13 below (categorized by weight) from which a load could be selected to fit the criteria. It should be noted that priority for testing does not imply an operational priority or test sequence of loading or unloading.

TABLE 13

MAJOR EQUIPMENT OPTIONS FOR LOADING

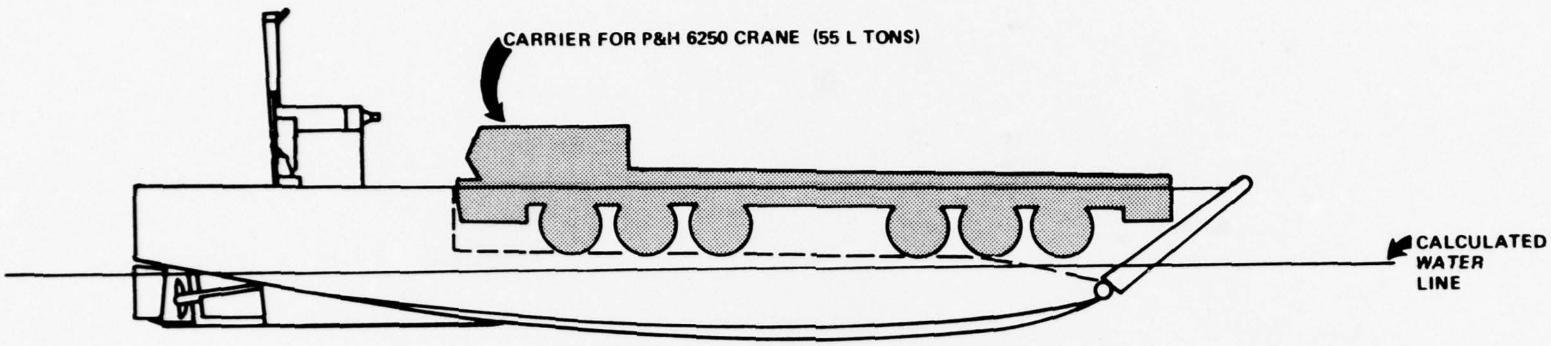
Lighterage Options	Crane (Disassembly) Options	Causeway/Barge Options
LCU-180 long tons	250-ton (tactical) - 98.2 long tons	"B" DeLong - 650 long tons
3 x 15 Causeway 60.3 long tons	140-ton (assembled) - 72.3 long tons	3 x 15 causeway - 60.3 long tons
LCM8-57.8 long tons		
LACV-30-27.7 long tons	250-ton (administrative)- 54.4 long tons	
	140-ton (tactical) - 42 long tons	

Having identified the lifts to be made and the ship space available for loading, a load analysis was made to determine the maximum capacities of each ship type (breakbulk, heavy-lift breakbulk, LASH, SEABEE, and NSS containership) to accommodate these major items of selected LOTS heavy equipment. (Accommodating all LOTS test lifts in a single test "shipload" minimizes costly charter fees.) Equipment loading options were determined by first calculating the total usable deck space on each ship with each particular heavy equipment item that could be loaded on that ship type (for example, loading the weather deck of a containership to capacity with 12 LCM8s, then seven LACV-30s, etc.). Then, using a line diagram, deck space trade-offs were made to develop a mixed load that included all heavy equipment items, or at least as many as usable deck space permitted. This approach initially helped determine the amount of equipment which could be loaded as well as providing a tool for visualizing ship capacities.[1/]

A key feature in the conventional breakbulk and LASH ship pretests is the feasibility of loading the P&H 6250 carrier in an LCM8. This load configuration may be critical to the successful deployment of the 250-ton crane in instances where sealift for LCUs is not available.[2/] If feasible it will provide for heavy crane deployment by the majority of the ships in the U. S. merchant fleet. There are several special matters to consider in this regard. The P&H 6250 must be disassembled into its administrative shipping configuration in order to be transported by the LCM8. The margin of difference in the size of the carrier and the well deck of the LCM8 is very small (see Figure 7). Also, the carrier has a low center of gravity and its tridems do not have individual suspension, making the carrier's drive-on/drive-off operation difficult. As a result, the LCM8's well deck will require special ramping and possibly a load spreader if the deck is not sufficiently reinforced. These limitations should be physically checked and any modification identified as soon as practicable after the crane is available.

[1/] These "capacity diagrams" are referred to in subsequent discussions of loading and unloading and are contained in the individual ship pretest descriptions that follow.

[2/] Another possible alternative to the LCM8 as a lighter for the 6250 carrier is the causeway ferry. Although probably more of a stability problem than the LCM8, it should be investigated if dimensional or other constraints rule out the use of the landing craft.



NOTE: This figure illustrates the close fit of the crane carrier in the LCM8. Methods to position the carrier in the LCM8 or counterweight the LCM8 so that the craft (with its preload) can be hoisted aboard a LASH by the lighter gantry crane are being evaluated.

FIGURE 7. LCM8 BEING USED FOR LARGEST PIECE OF 250-TON CRANE (ADMINISTRATIVE MOVE CONFIGURATION)

Finally, it should be noted that the equipment recommended for loading is not intended to limit or preclude the Joint Test Director from including additional equipment on any of the test ships. Such test add-ons are encouraged so long as they can be accommodated within the time and resources available and will not jeopardize the primary joint test objectives.

In the paragraphs which follow, there are included several ship diagrams with templates added. These diagrams are intended to illustrate feasible load concepts but are not intended to replace deck or profile diagrams which would be required in the final load planning, nor are they intended to restrict test personnel as to the final locations of equipment loaded.

CRANE SHIP-TO-SHORE MOVEMENT AND REASSEMBLY SUBTESTS

The critical nature of the shoreside crane subsystem to the Army LOTS concept warrants a series of subtests which can be accomplished in conjunction with the ship pretests. The ship-to-shore movement and the reassembly of both the 140-ton and the 250-ton cranes from various disassembled configurations will be accomplished as extensions of two of the ship deployment evaluations. To preclude unnecessary wear and maintenance, pretests have been designed to avoid repeated reassembly operations of the cranes wherever possible. For example, having reassembled the 250-ton crane during the conventional breakbulk ship test, there is no requirement to completely repeat this event. In the LASH and containership tests, the carrier will be the only component involved. Table 14 summarizes crane subtest and the levels of disassembly involved. Further discussion is contained in the paragraphs relating to the pretests aboard each type ship.

CONVENTIONAL BREAKBULK SHIP

Pretest General Description

This pretest involves the loading in-port of selected LOTS system items and movement to an off-shore anchorage for ship unloading.[3/] Both the 140-ton and the 250-ton cranes will be lightered to a pre-selected and prepared beach site where they will be placed in an operational status. The sequencing of unloading will be such as to release the ship as soon as possible. Estimated duration of ship use time is three days.

For this pretest it is recommended that an MSC controlled fleet ship with a 70-ton boom capacity be employed. These ships (hull designation C457) have the capability to use their jumbo boom on two holds (three and four) and have three separate, side-by-side hatch squares (each 42'6" by 16'). Such features provide more than twice the amount of space available for stowage on most ships. Figure 8 illustrates various capacities for the LOTS heavy equipment selected for loading.

[3/] It is not possible to outline specifically the sea and weather conditions under which the off-shore discharge phase of the ship tests should be conducted. As a general guideline, however, planning for these pretests should tend toward maximizing favorable conditions rather than attempting to obtain a wider range of environmental exposure. While the latter approach may be appropriate for certain sustained events in the main tests, it is not considered practical or prudent during these initial evaluations. Restrictions of ship owners/operators may also have a major influence on scope of the proposed off-shore operations.

TABLE 14

SHIP-TO-SHORE MOVEMENT AND REASSEMBLY
SUB-TEST FOR LOTS CRANES

Ships \ Cranes	140-Ton Crane: Tactical Disassembly 1/ (52' length)	140-Ton Crane: Tact. Disassembled Without Boom Base (33' length)	250-Ton Crane: Administratively Disassembled 2/	250-Ton Crane: Tactical Disassembly 3/	Remarks
Conventional Breakbulk	X		X		140-ton crane assist in the reassembly of 250-ton crane
Heavy-lift Breakbulk	X 4/			X	
Containership 5/					
LASH 6/		X			
SEABEE				X	250-ton crane will be loaded on the DeLong "B". Boom removal (except base) only

1/ Tactical disassembly of the 140-ton crane is defined as the reduction of the crane into three major components: the carrier with upper and boom base; the counterweight; and the remaining boom sections. Assembly time has been estimated as six to seven hours with 6-10 personnel.

2/ Administrative disassembly of the 250-ton crane is defined as the detailed reduction of the crane into a state compatible for administrative movement. In this state the boom sections and counterweights are removed; the upper is separate from the carrier; and the components such as the outriggers, cable, and gantry are removed. This reduces the largest component (the carrier) to 61 short tons. Assembly time has been estimated as two to three days and requires good lift equipment and an experienced crew of 6-10 personnel.

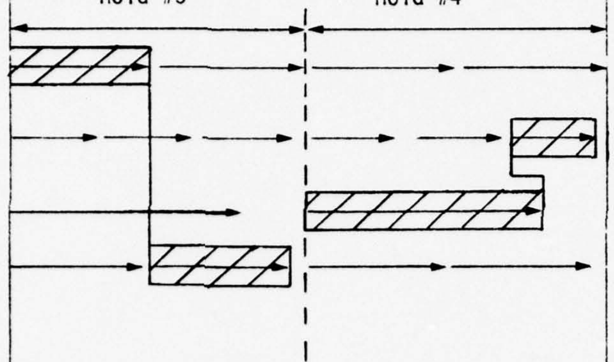
3/ Tactical disassembly of the 250-ton crane is defined as the minimum breakdown for shipment. In this configuration the crane is separated into three components: the boom sections (including the base), the three counterweights, and the carrier with upper. Assembly time is estimated as 8-10 hours with 6-10 personnel.

4/ If required for assembly of 250-ton crane.

5/ 140-ton crane will be loaded to provide the containership with an off-load capability. 250-ton crane load is carrier only. No reassembly subtest.

6/ Carrier only. 250-ton crane is pretest load, but no other component included. Therefore, there is no reassembly of the 250-ton crane.

EQUIPMENT LOADING OPTIONS
C457 BREAKBULK SHIP
(Holds 3 and 4, Including Weather Deck)

Test Priority	Equipment to be Test Loaded	Single Item Capacity*	Stowage Utilization Comparison (In terms of Fore and Aft Stowage Below Decks and Athwartship Stowage on the Weather Deck) Hold #3 / Hold #4	Remarks
				WEATHER DECK
1	1-LCM8	4		Two could be loaded on each hatch square
2	1-250-Ton Crane Carrier	6		
4	1-LACV-30	2		**Extends over fwd edge of hatch square.**
5	1-3x15 Causeway	4		One high stacking, causeway will extend 8.8' over each side of ship.
				HOLD STOWAGE
3	1-140-Ton Crane	14	(No illustrations are attempted since test loads do not approach the capacity of either of these holds and no trade-off analyses are required.)	
6	1-Toplift Loader	68		
7	1-Sideloader	40		

*Capacity is based on the estimated exclusive loading of only one type item. A sample mixed load is indicated by the cross-hatched area.

FIGURE 8. ILLUSTRATION OF C457 BREAKBULK SHIP CAPACITIES FOR SELECTED LOTS HEAVY EQUIPMENT

The pretest load will include the following items loaded on the weather deck: an LCM8, a 3 x 15 causeway assembly, the carrier of a P&H 6250 (250-ton) crane, and a LACV-30. The below decks load will include the following equipment: a P&H 9125 (140-ton) crane with the counterweight and boom removed (except for the base); the 140-ton crane boom sections (mobile-loaded on an appropriate semi-trailer, as preferred, to reduce shoring and handling requirements and minimize possible damage); the counterweights for the 250-ton crane; the boom sections of the 250-ton crane (mobile-loaded, if preferred); a toplift loader; and a sideloader. Figure 9 is a profile and overhead loading diagram for pretest loads.

Rationale

One of the primary functions of the test is to determine whether the recommended equipment, which approaches the weight capacity of the boom and which is outsized as well, can be loaded in-port and unloaded off-shore without use of special facilities. If feasible, a deployment means will be relatively assured for a ship-to-shore and shoreside LOTS capability. This pretest and the capabilities being evaluated are based on the assumptions that:

- Disassembly of the 250-ton crane into its administrative shipping configuration and subsequent reassembly in the LOTS objective area is feasible within the scenario time-frame.[4/]

- In a situation where no LCU lift is available, LCM8s and causeway sections could provide ship-to-shore lighterage support for unloading heavy equipment and cargo. The LACV-30 could be used as additional support for appropriate cargo/equipment and subsequent container throughput operations.

A second primary objective of this pretest is to evaluate the capability to reassemble the 250-ton crane in the field. This is the only ship pretest in which the 140-ton crane will be used to completely reassemble the 250-ton crane from its administrative diassembled configuration (see Table 14).

The equipment selected for test loading can provide a limited capability for the ship-to-shore movement of LOTS equipment and together with the assembled cranes can subsequently provide a limited throughput of containers, provided there is a ship unloading subsystem. Verification of this deployment capability will eliminate total reliance on a limited number of specialized ships as the only means available to deploy a LOTS system capability. (See discussion under "Heavy-Lift Breakbulk Ship" which follows.)

The causeway to be embarked could be used as lighterage to assist the ship unloading. It has more space for loading than an LCM8 but requires tug support or some means of propulsion. The primary objective in loading the causeway section is to test alternative means for its deployment rather than its lighterage role.

[4/] The effect of assembly time, once more field experience and data are available, will be considered in the overall LOTS deployment analysis.

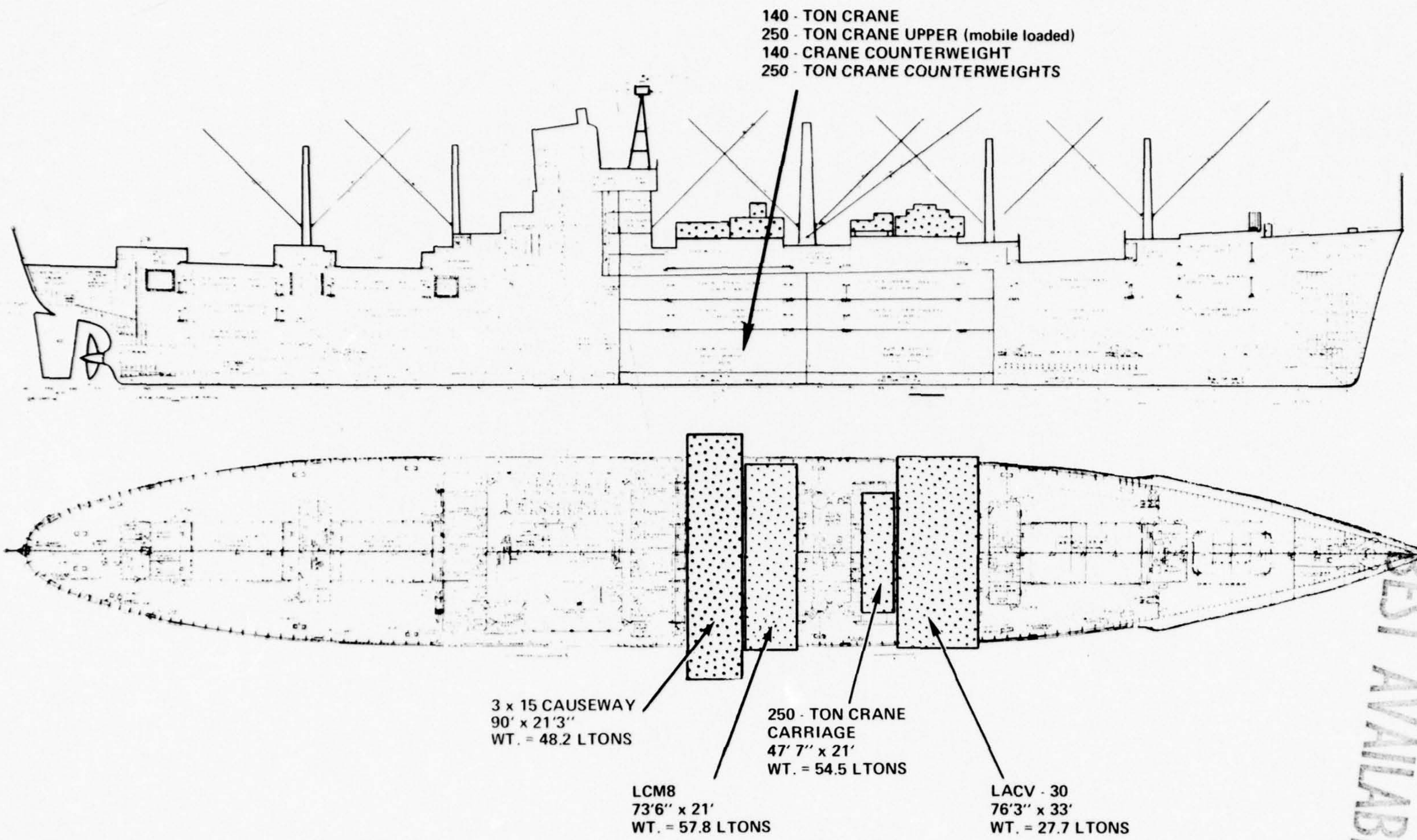


FIGURE 9. C457 BREAKBULK SHIP (70-TON BOOM) LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT

Loading Procedures

The lower holds of both numbers three and four holds have the greatest clearances (approximately 17 feet). Thus, either is suitable for loading the height-critical items of equipment, such as the P&H 9125 crane and the mobile-loaded upper section of P&H 6250 crane, both of which should be approximately 13 feet.[5/]

The sequence of loading/unloading is relevant to the extent that the sooner the 140-ton crane is off-loaded, the sooner it can be assembled in preparation to assist with the P&H 6250 on the beach. Thus, the hatch squares within the hold on the two levels directly above these items must either be cleared immediately or not overstowed. Configuration of the hatch squares and holds of the ship are such that one item can be off-loaded from the port side and the other from the starboard side (with the center hatch square overstowed and closed, or opened,as required).

It may be desirable that the hatch square to the level above the P&H 9125 remain open. This will expedite ship loading and the crane's readiness for operations on the beach. With the greater overhead clearance the crane's boom base and gantry can be left intact. (The boom base is required in order for the crane to be able to reassemble the remaining sections of its boom.) There are alternatives to leaving the hatch square open but they are more time consuming.

The P&H 6250 upper (mobile-loaded) would be loaded next on the side of the ship opposite from the P&H 9125. The hatch squares can accommodate the M162 low bed semi-trailer (37'3" x 12'). The width of the crane upper is approximately the same as that of the trailer.

Other trailers of lesser capacity with prime movers, as required, could be preloaded with boom sections and counterweights, and stowed either in the lower hold with the cranes or on the next level above. This will facilitate unloading counterweights and boom sections from lighterage at the beach if they are mobile-loaded on trailers. The sequence for unloading should permit a prime mover for the trailers and those trailers carrying the boom sections for the P&H 9125 to be off-loaded either just before or just after the unloading of the P&H 9125. The P&H 9125 counterweights would be the next elements to be off-loaded after the crane.

While the P&H 9125 is being reassembled on the beach, the P&H 6250 components will be unloaded. Therefore, in the loading process these items should precede the 9125 components. The last item which should be unloaded is the carrier for the P&H 6250. The LCM8 will probably require ramping to facilitate beach unloading.

[5/] The clearance requirement for the upper is unknown since the crane has just been received and as yet plans for mobile-loading have not been fully developed.

Below is a recommended sequence for loading/unloading.

Loading	Unloading
1. LACV-30	1. LCM8
2. P&H 6250 carrier (Ship's 70-ton boom changes holds)	2. Causeway section
3. P&H 6250 upper	3. Beach support equipment (i.e., sideloader, D-8 dozer, soil stabilization materials)
4. P&H 6250 components	4. P&H 9125
5. P&H 9125 counterweight	5. P&H 9125 boom sections
6. P&H 9125 boom sections	6. P&H 6250 counterweight
7. P&H 9125	7. P&H 6250 components
8. Beach support equipment (i.e., sideloader, D-8 dozer, etc.)	8. P&H 6250 upper (Boom shifts holds)
9. Causeway section	9. P&H 6250 carrier
10. LCM8	10. LACV-30

C41-C457 HULL COMPARISON

The C41 was selected initially as the most representative test type breakbulk ship (see section entitled "Ships to be Employed"). It is considered the breakbulk ship with minimum capability of deploying a nucleus LOTS system. Because it is not included in MSC assets, a substitute ship type was recommended. The same loads which are to be pretested in the C457 hull type would have been test loaded on the C41. Because the jumbo boom on a C41 can be used at only one hatch, two modes of loading would have been required. Figures 10 and 11 illustrate the proposed loading scheme using the C41. (This data is shown for information only.)

HEAVY-LIFT BREAKBULK SHIP

Pretest General Description

Pretesting of the heavy-lift breakbulk ship will consist of the in-port loading and off-shore discharge of some of the heaviest and largest LOTS equipment items. The test is intended to confirm the ship's capabilities to accommodate a mixed on-deck load of LCUs and causeway sections and to check the adequacy and safety of the special slings and rigging devices and procedures that will be required to accomplish test lifts. Equipment to be loaded will include a 3 x 15 causeway section and two LCUs on the weather deck. Below decks loading will include a LARC-LX, beach support equipment (such as a D-8 dozer), and the tactically disassembled 140-ton and 250-ton cranes. The hold capacity of a heavy-lift ship is illustrated in Figure 12 as well as the weather deck capacity above that hold. The suggested pretest load is illustrated in Figure 13.

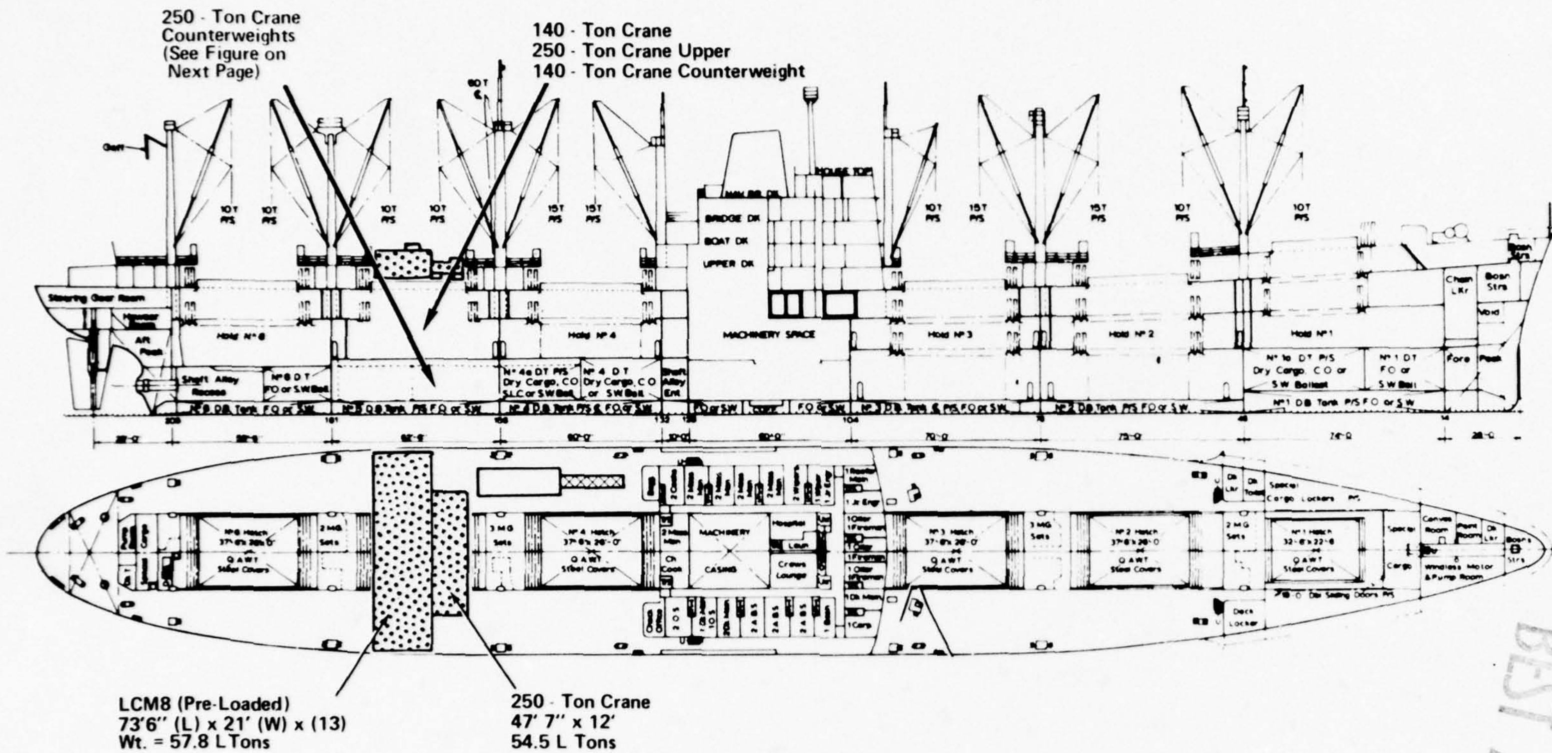


FIGURE 10. C41 BREAKBULK SHIP PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT - MODE I

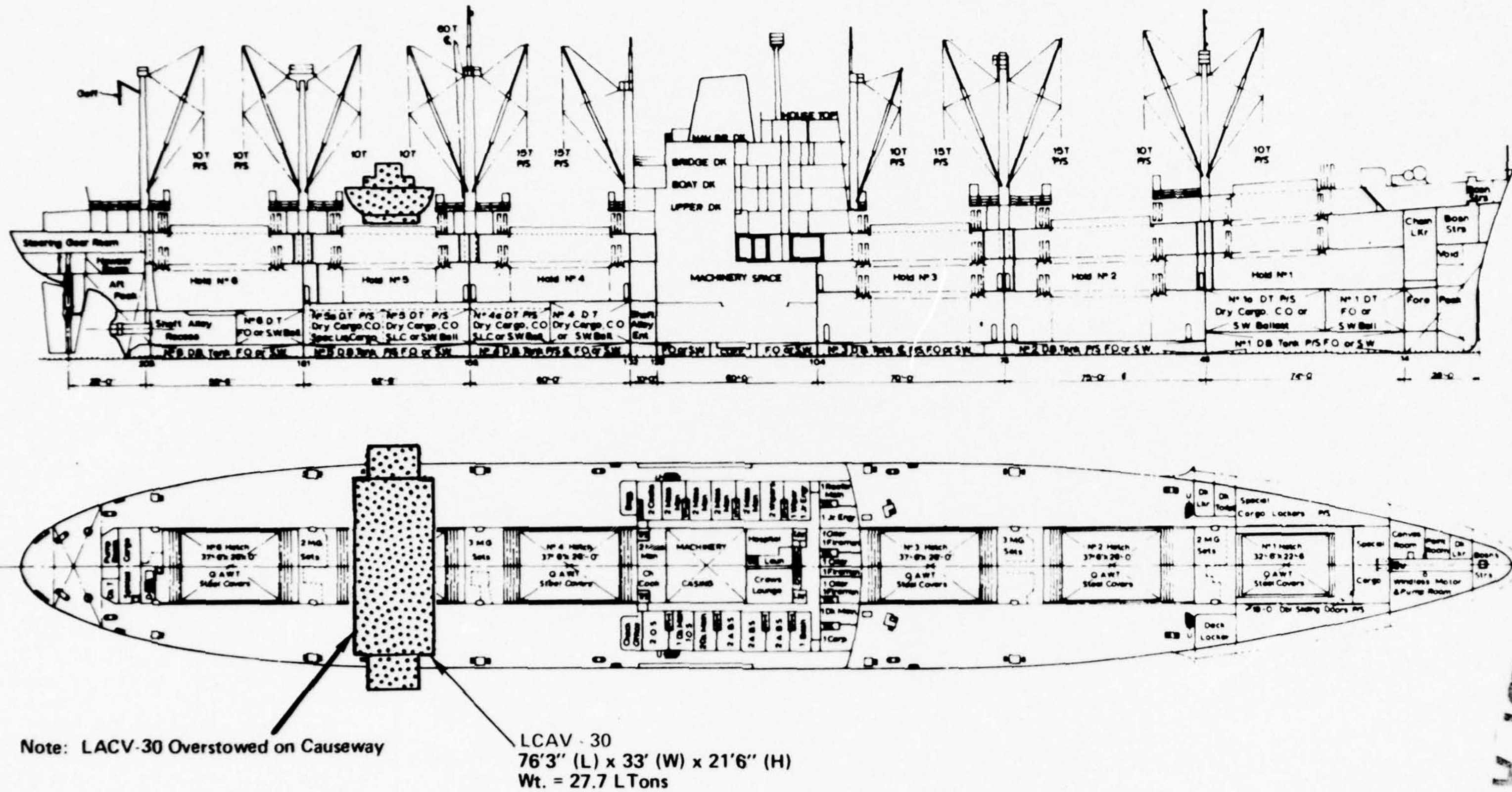
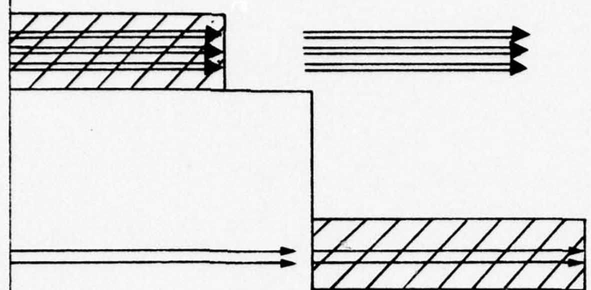


FIGURE 11 C41 BREAKBULK SHIP PRETEST LOADING PLAN FOR
SELECTED LOTS HEAVY EQUIPMENT - MODE II

EQUIPMENT LOADING OPTIONS
HEAVY-LIFT BREAKBULK SHIP (TRANSCOLORADO)
(Holds 3 and 4, Including Weather Deck)

Test Priority	Equipment to be Test Loaded	Single Item Capacity*	Stowage Utilization Comparison (In Terms of Fore and Aft Stowage)	Remarks
				WEATHER DECK
2	1-Causeway (3x15)	12		Capacity attained by stacking two high on each hold. The stacking limit is unknown, thus, it may be possible to carry more sections.
3	2-LCU (1466 Class)	4		Other LCU classes can be carried without difficulty, but quantity which can be loaded will not change.
				HOLD STOWAGE
1	1-250-Ton Crane (Tac Dissy)	18	(No illustrations are attempted since test loads do not approach the capacity of either hold 3 or 4 and no trade-off analyses are required to accommodate the test load.)	Check tests will be required to verify.
4	1-LARC-LX	5		Stowage limited to hold 3.
5	1-140-Ton Crane (Tac Dissy)	29		
6	1-Toplift Loader	69		
7	1-Sideloader	44		

* Capacity is based on the estimated exclusive loading of only one type item. A sample mixed load is indicated by the cross-hatched area.

FIGURE 12. ILLUSTRATION OF HEAVY-LIFT BREAKBULK SHIP CAPACITIES FOR SELECTED LOTS HEAVY EQUIPMENT

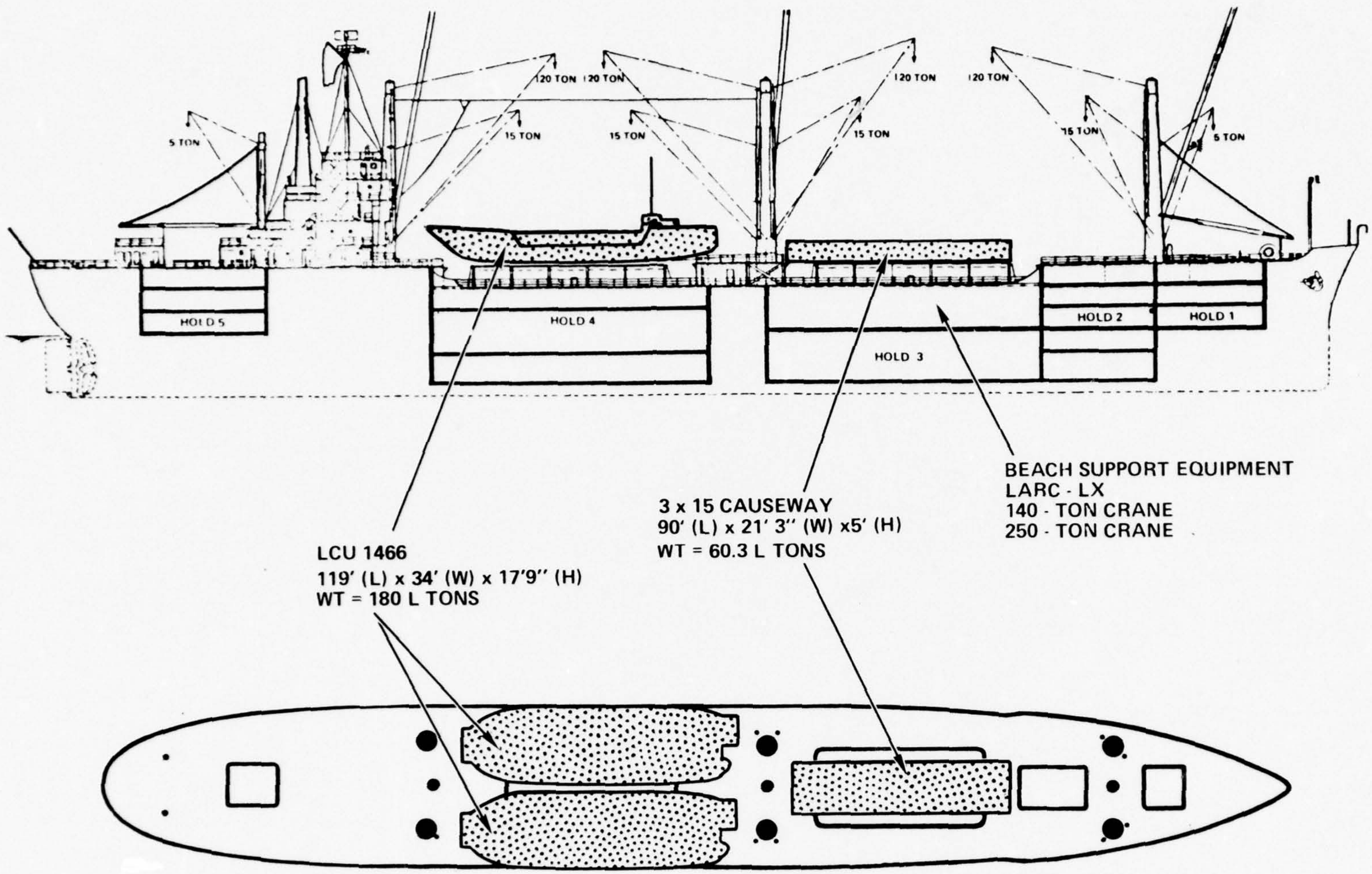


FIGURE 13. HEAVY-LIFT BREAKBULK SHIP PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT

Rationale

Only two breakbulk ships in the U. S. merchant flag fleet have the capability to load and off-load LCUs and other heavy, outsized LOTS system equipment in an essentially ready-for-use configuration. The fact that only two such ships are in service is a recognized limitation of their deployment potential. However, because they do have such unique capabilities and are available as part of the MSC controlled fleet tends to enhance their relative significance. In situations where neither amphibious shipping nor SEABEE ships are expected to be available, they provide the only assured LCU deployment capability.

In addition to assisting in evaluating deployment alternatives, other loading and unloading data such as the time required to switch rigging to boom-marriages can be confirmed in the test events. Also, requirements such as quantities and types of griping and chocking gear for causeway sections can be validated prior to the main test. These data will contribute to refinement of main test planning and subsequent deployment analysis.

Although never employed in a LOTS role, it is recognized that of all the ship types in the pretest design, the heavy-lift breakbulk ship has most extensively demonstrated its capability to handle loads comparable to those which comprise the LOTS system equipment. It would be highly desirable to physically verify these capabilities in an off-shore environment.

Because of the time required for unloading the 250-ton crane from an LCU (estimated to be rather lengthy), one LCU was included in the test load to be dedicated for this purpose. The second LCU will be used for off-loading the remaining equipment.

Loading and Unloading Procedures

Hold number three has the greatest overhead clearances and is better suited for loading the two cranes tactically disassembled (with their boom bases and gantrys intact). The hold has sufficient space available to stow trailers (mobile-loaded with boom sections) and other supporting equipment that may be required. Beach preparation materials and equipment could also be stowed in this space, although it may be necessary to use both levels depending on the amount of additional equipment to be included.

The sequence for loading and unloading is based on the concept that the two cranes, which are the slowest items to off-load from landing craft, would be the last items to be unloaded from the ship to facilitate early release of the ship. As with other breakbulk ships, cargo to be off-loaded first, must be loaded last. If this recommended sequence is overly restrictive, modifications may be recommended by the Joint Test Director.

Loading	Unloading
1. P&H 6250 boom sections	1. LCU
2. P&H 9125	2. Causeway section
3. P&H 6250	3. LCU
4. P&H 9125 boom sections	4. LARC-LX
5. Beach support equipment (as required)	5. Beach support equipment (as required)
6. LARC-LX	6. P&H 9125 boom sections
7. Causeway section	7. P&H 6250
8. LCU (load at anchor)	8. P&H 9125
9. LCU (load at anchor)	9. P&H 6250 boom sections

As noted above, loading of the LCUs must be accomplished at anchor. The ship must load from both sides and conduct ballasting operations during the loading.

Slings, rigging, lifting shackles, spreader bars, and chocking gear will be critical to successful tests. Liaison with the ship will provide some indication as to how much of this equipment the ship can provide, but for the most part these are responsibilities of the embarking force to provide when outsized equipment is to be loaded.

CONTAINERSHIP

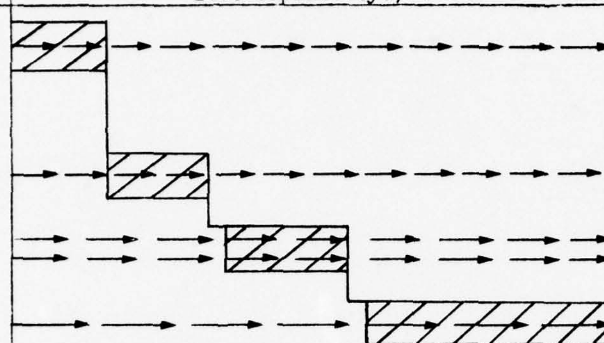
Pretest General Description

This pretest will consist of the in-port loading of a containership and the off-shore discharge of the selected LOTS system equipment using 140-ton mobile cranes on the deck of the vessel. Based on current delivery forecasts, cranes to be used in the pretest will be those organic to the terminal service company (container). They are also considered to be generally representative, for pretest purposes, of the mobile cranes that are being evaluated as part of the Navy-sponsored crane-on-deck project.

The equipment to be loaded and unloaded by the cranes will be an LCM8, LACV-30, 3 x 15 causeway, and carrier for the P&H 6250 (250-ton) crane. Temporary hatch bridging will have to be provided pending design and procurement by the Navy of its standardized bridging kit which is expected to be available for the main LOTS test, but not for the pretests. Figure 14 gives the weather deck load capabilities of a C685 with the cross-hatched area representing the capability to handle a mixed type load. The quantity of equipment to be loaded by the two cranes is given in the second column. If single crane lifts prove infeasible, test lifts are recommended using two cranes in tandem.[6/] If a tandem

[6/] Technical feasibility of single crane lifts should be established, prior to acquiring the test ship, by shoreside crane trials using test weights and calculated radii which simulate ship test conditions.

EQUIPMENT LOADING OPTIONS
C685 CONTAINERSHIP (NSS)
(Weather Deck Only)

Test Priority	Equipment to be Test Loaded	Single Item Capacity*	Stowage Utilization Comparison (Space Allowances for Two Crane-on-Deck are Made. Assumes Single Crane Lift Capability.)	Remarks
1	1-LCM8	12		Stowed athwartship. Preliminary tests may show that a tandem crane lift is required.
2	1-Causeway (3x15)	12		Calculated for stacking only one high.
3	1-250-Ton Crane Carrier	20		
4	1-LACV-30	7		

*Capacity is based on the estimated exclusive loading of only one type item. A sample mixed load is indicated by the cross-hatched area. Capacities will be drastically reduced if tandem lifts are required for tandem lifts of the above items.

FIGURE 14. ILLUSTRATION OF C685 NSS CONTAINERSHIP CAPACITIES FOR SELECTED LOTS HEAVY EQUIPMENT DEPLOYMENT

crane test is required, the LARC-LX should be added as a test item. Figure 15 illustrates the ship load for the preferred approach to the pretest (single crane) and Figure 16 illustrates the ship load and unloading sequence to be used if tandem lifts are required.

Rationale

The characteristics and anticipated employment of a containership tend to make it less suitable as a LOTS system deployment ship than the breakbulk ships or bargeships. However, containerships represent a substantial part of the total sealift assets and have a high probability of being employed in a contingency. Without prejudging the merit of such an approach, it is recommended that the feasibility of using this type ship be evaluated as a potential supplement to other type vessels normally considered for a deployment role.

As indicated, the tandem lift pretest is a contingency option to be used only if single lifts prove to be infeasible. Calculations show the single lifts can be made but approach the safety limits of the crane. Upon delivery of the cranes, initial checks are required to verify these calculations.

If tandem lifts are required, a considerable amount of repositioning of cranes on the deck of the ship will be required. Without a suitable hatch bridging kit, which will not be available during the pretest period, a great deal of time will be consumed in moving both the cranes and expedient deck reinforcing materials into position for each lift. Also, space must be left at appropriate locations between the items to be loaded and off-loaded, (see Figure 16) to permit the repositioning of the cranes, thus degrading the ship's load carrying potential.

Loading and Unloading Procedures

The 140-ton cranes can be moved to the test ship by LCUs and loaded directly using a service-owned 100-ton floating crane (YD or BD). The mobile cranes should be located at opposite ends and at opposite sides of the ship for maximum stability. To minimize the cranes' required lifting radii, the ship's deck should be shored and reinforced up to the gunwales and the long axis of the crane should be perpendicular to the centerline of the ship with the carrier cab inboard. (For deck and hatch reinforcement calculations see Appendix C.) This arrangement will provide the crane with the greatest lifting capacity possible. A technique that could be used to reduce the radius for lifting the causeway section is illustrated in Figure 17.

To help maintain stability and trim of the ship during unloading operations and to minimize crane load derating which may result from listing, it may be desirable to match drafts by having each crane simultaneously off-load. An LCM8 would be off-loaded from the port side aft while a causeway section, which approximates the weight of the LCM8, would be off-loaded forward over the starboard side. This procedure would be repeated for the LACV-30 and the 250-ton crane carrier. In the latter case, the weight difference between the two items should not cause any appreciable listing. If the tandem crane test is required, it may be necessary for the cranes to be positioned closer to the ship's centerline since any counterbalancing effect will be lost. The sequence of unloading for a tandem lift is discussed in Figure 16. The only significant priority for unloading is that the LCM8, which would be used as lighterage for the crane carrier, must precede it. Table 15 provides current information on LCM8 weights and other lift data.

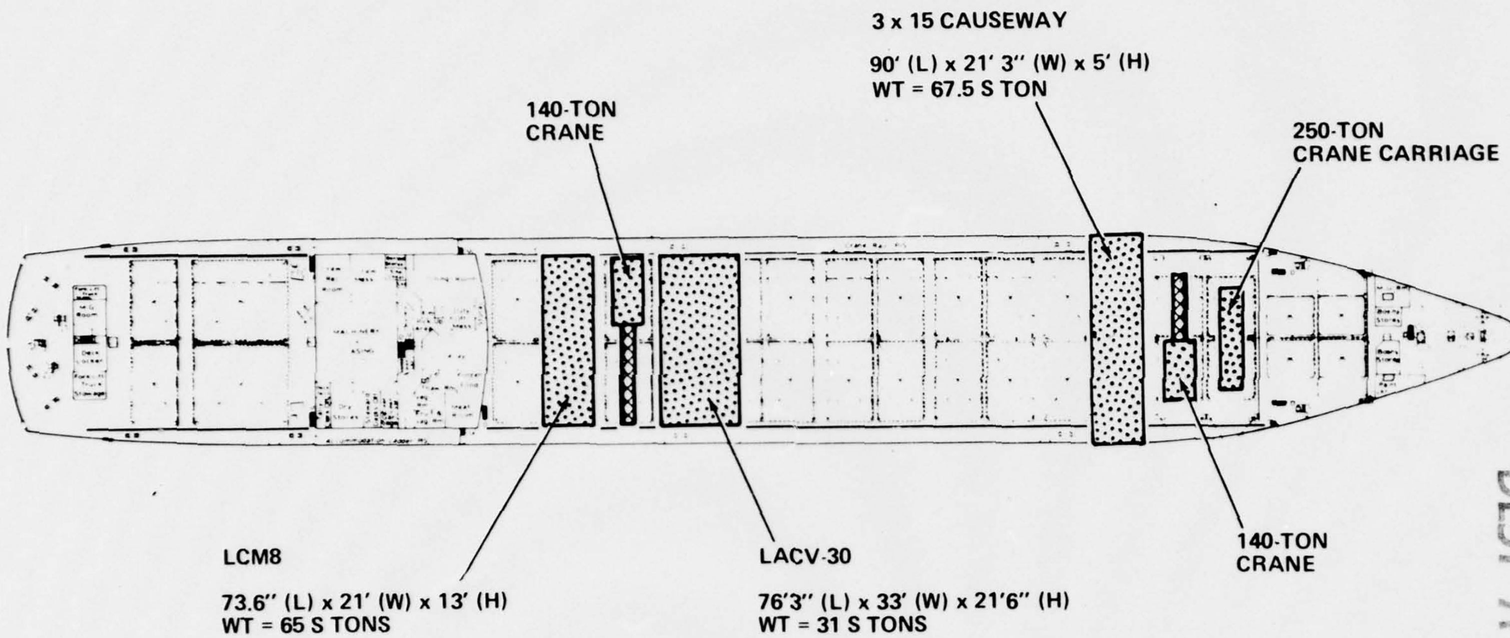
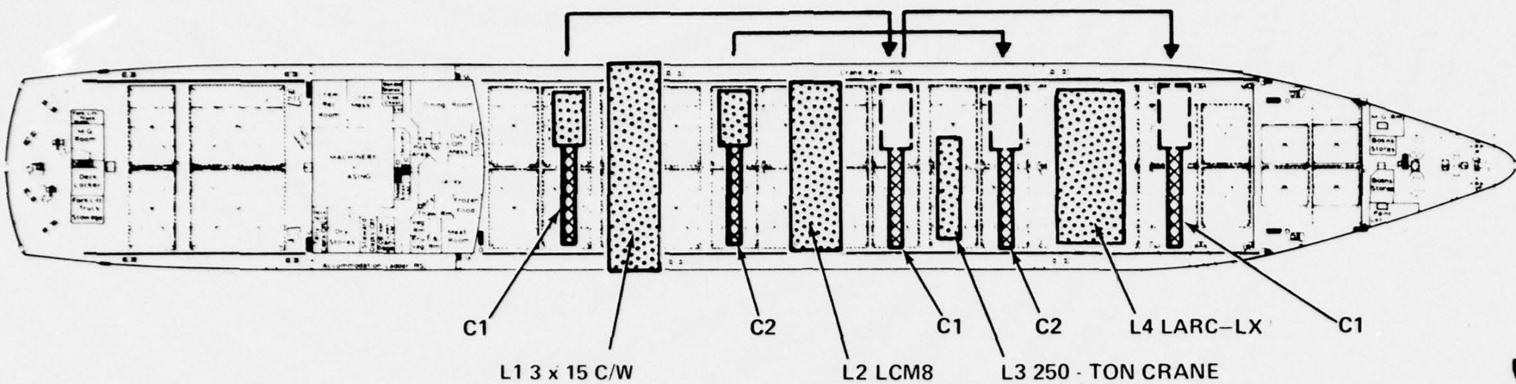


FIGURE 15. C685 NSS CONTAINERSHIP PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT (SINGLE CRANE LIFTS)



SEQUENCE OF UNLOADING

1 - Cranes one and two (C1 and C2) off-load lift one (L1), a 3 x 15 causeway section.

2 - Crane two (C2) shifts lift two (L2), an LCM8, to one side of the ship to permit crane one to pass around the LCM8.

3 - When crane one is in position, both cranes lift the LCM8 in unison.

4 - Crane one remains in position. Crane two moves to opposite side of lift three (L3), a 250-ton crane carrier, and both cranes unload lift three in unison.

5 - Crane two remains in position. Lift 4 (L4), a LARC-LX, moves forward sufficiently to permit passage of crane one to the opposite side of the LARC-LX.

6 - Cranes one and two off-load lift four.

FIGURE 16 C685 NSS CONTAINERSHIP PRE-TEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT (TANDEM LIFTS)

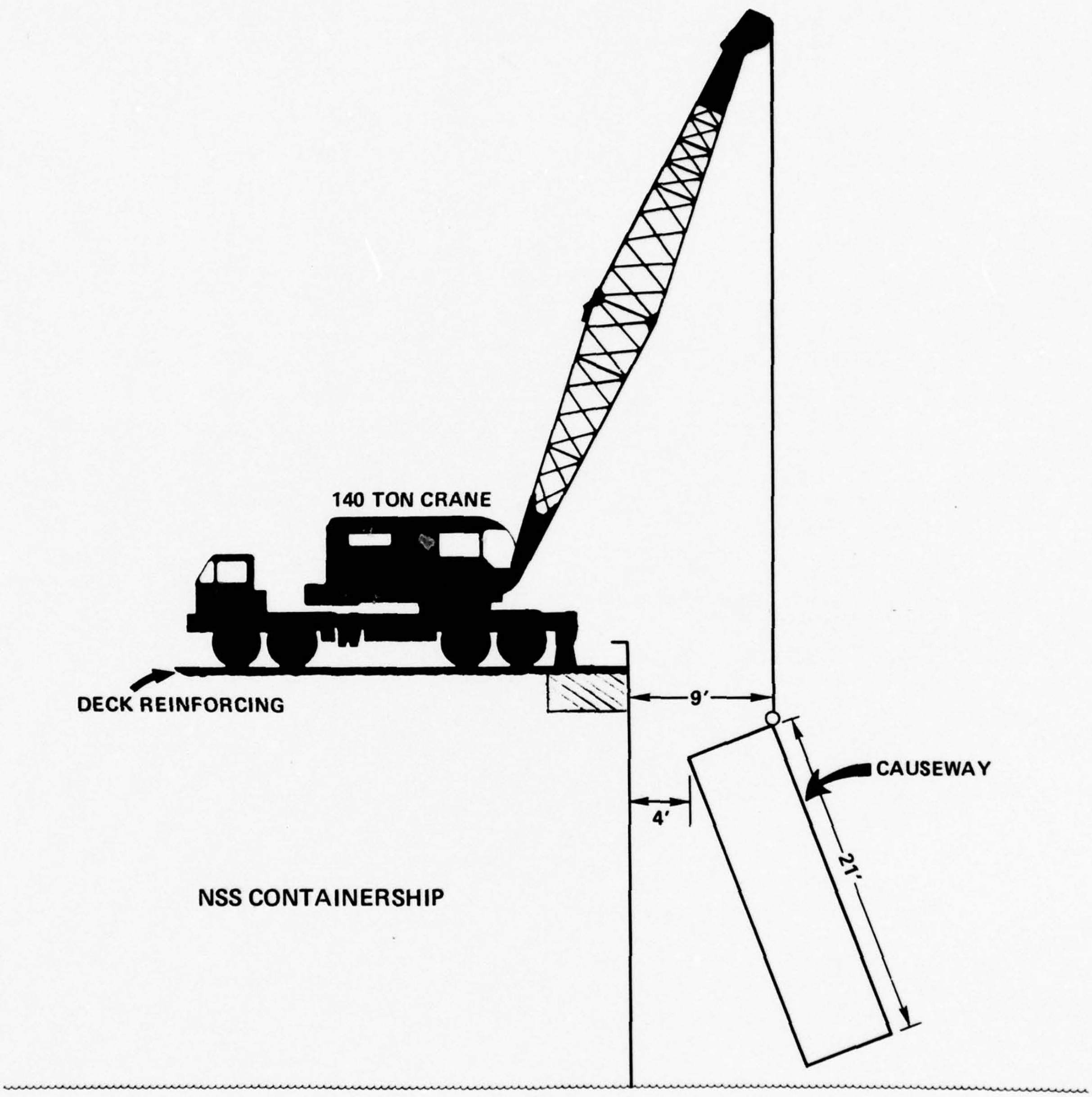


FIGURE 17. PROPOSED LIFTING TECHNIQUE FOR LOADING AND LAUNCHING CAUSEWAY

TABLE 15
LCM8 DATA SUMMARY [1/]
(Mod 1, Steel)

Length (overall)	73.6'
Maximum Beam	21.05'
Height (without cradle)	15.55'
Draft (light):	
Forward	3'
Aft	3'6"
Draft (loaded):	
Forward	3'
Aft	5.2'
Fuel Capacity	875 gals.
Fuel Consumption	34.16 gals./hr.
Number of Crew	5
Maximum Displacement	260,000 lbs.
Hoisting Weight[2/]	132,000 lbs.
Light Load Displacement[3/]	124,000 lbs.
Cargo Capacity[4/]	128,000 lbs.
Cargo Compartment Dimensions (to ramp):	
Length	42.75'
Width (maximum)	16'
Width at Ramp Opening	14.5'
Hoisted by	Sling
Diameter sling cable	2"
Height of Sling (attached for lifting)[5/]	24.5'
Sling Test Requirements[6/]	268,800 lbs.
LCM8 Lifting Point Safety Factor (times wt. of craft)[7/]	6

[1/] References: (a) U.S. Navy, NAVSHIPS 0902-820-0002, (Chapter 9820), Naval Ships Technical Manual, Boats and Lifesaving Craft (Incl. Inflatable), Boat Hoisting and Stowage, and (b) NAVSEA 0900-LP-084-3010 Data Book for Boats and Craft of the U.S. Navy.

[2/] Reference: Section V, Table 1, NAVSHIPS 0902-820-002 (Chapter 9820). Hoisting weight is defined as, "The weight of the boat completely fitted out and ready for service with machinery and electrical installations in operating condition. All outfit, on board repair parts, navigational and lifesaving equipment, or their equivalent weights must be on board. Weights representing the crew at 165 pounds per man must also be on board; fuel tanks must be full except for special cases."

[3/] Reference: Paragraph 9290.172 NAVSEA 0901-290-002. Light load displacement is defined as, "The weight of the boat complete-ready for service with machinery and electrical installation in operating condition, fitted with all navigating lights and life saving gear, but without ammunition, stores, complement, fuel and other items of consumable or variable load."

[4/] This is a revised capacity to be published by NAVSEA in an updated version of NAVSEA 0902-820-0002. Reference: interview with Mr. John J. Melescue, NSEA 944321 of 23 December 1975.

[5/] Reference: Landing Craft Mechanized LCM(8)-Mod-1 Boat Hoisting Gear, Contract Plan LCM(8) 645 1847024 dated 4 February 1965.

[6/] Contract plan (see footnote [5/]) requires the testing of each leg to double its normal anticipated working load which does not readily approach the maximum capacity of the cable (approximately 179 short ton safe working load).

[7/] Lifting points on the LCM8, while designed to accommodate the hoisting weight of the LCM8, are required by U. S. Navy design specifications to support six times the weight of the craft in order to accommodate stresses resultant from surging seas. (Reference: NAVSEA Technical Manual 9820, Section 8, paragraph 9820.154.) The heaviest LCM8 preload (a 61-short ton P&H 6250 carrier) and the LCM8 itself appear to be within these specifications, although exceeding the recommended working load (see LASH pretest description which follows). Calculations relating to this capability can be verified by Norfolk office of the Naval Ship Engineering Center, which possesses the requisite drawings and specifications for accomplishing this task.

LASH

Pretest General Description

For LASH pretests the ship will be loaded in-port and off-loaded at an anchorage off-shore. As envisioned in this report, unloading will be accomplished in two phases. In the first phase LOTS equipment will be unloaded from landing craft across a Ft. Story beach site which can be prepared ahead of time. In the second phase, equipment and barges may be unloaded at a separate site in conjunction with "Solid Shield 76" exercises. It is recognized that operational constraints may limit unloading to one objective area. The test description is predicated on a two-objective area scenario, but a change would not affect the load/unload sequence.

The phase one portion of the pretest will be the only event which includes reassembly of the 140-ton crane from a tactical disassembly configuration with the boom base removed. Phase one of the pretest involves the use of preloaded LCM8 craft and a lift beam designed for employment with LASH ships. Two LCM8s will be preloaded with boom sections (mobile-loaded) and the counterweight of the 140-ton crane. Both craft will be loaded simultaneously using the port and starboard hook-up points of the lift beam. A third LCM8 preloaded with the 140-ton crane (less counterweight and boom sections) will also be loaded. A fourth LCM8 to be embarked will be preloaded with a 250-ton crane carrier. A 20-ton truck-mounted crane, which will be used to assist in the reassembly of the 140-ton crane, will also be loaded. The final item to be loaded for the Ft. Story test will be the LACV-30, subject to verification that such a lift is feasible with the LCM8 lift beam. Figure 18 illustrates sample loads for the LASH, with the cross-hatched area representing the pretest load.

Equipment to be loaded for the phase two discharge currently includes three causeway sections (3 x 15), one warping tug (3 x 15), two LCM6 causeway tender boats, and a 30-ton capacity crane. In addition, four LASH barges will be loaded with cargo for discharge operations possibly in conjunction with the joint "Solid Shield 76" Exercise.

Rationale

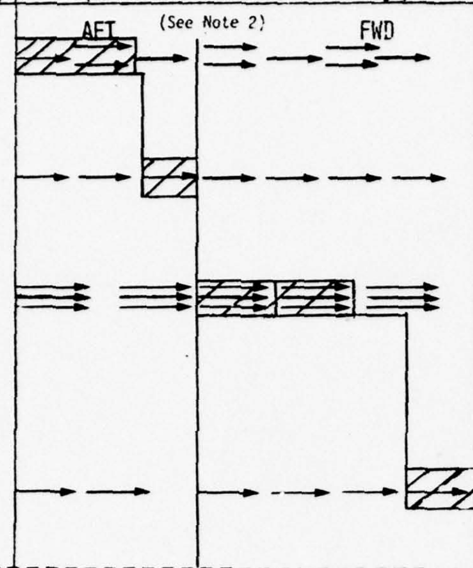
This pretest will verify the ship's capability to lift two preloaded LCM8s simultaneously and the capability to load an LCM8 preloaded to near maximum authorized weight capacity of the lift beam which has been certified for a maximum symmetric lift of 186 long tons and an asymmetric lift of 93 long tons. Both of the above proposed lifts fall within these specifications, but such lifts have never been tested under operational conditions. The loading and discharge of this equipment precedes subsequent shoreside events relating to the ability and timing required to make the 140-ton crane operational in the field. To assist in this latter operation, a 20-ton rough terrain crane was added to the list of equipment to be embarked.[7/]

Within the context of the overall test objectives, it is considered appropriate to examine alternative deployment means for causeway sections and other selected amphibious support equipment. The Navy is developing techniques and hardware to provide such a capability on the LASH.[8/] In case this developmental effort is not yet completed, it should be possible to employ some interim loading methods such as counterweighting the causeway sections to accomplish pretest events.

[7/] Smaller materials handling equipment such as a rough terrain forklift may be adequate for crane reassembly and may be substituted for the 20-ton rough terrain crane if desired.

[8/] One such item of equipment is a cantilevered lift beam which would significantly enhance LASH ship deployment capability.

EQUIPMENT LOADING OPTIONS
LASH
(Weather Deck Space Only)



Test Priority	Equipment to be Test Loaded	Capacity 1/	Stowage Utilization Comparison (In Terms of Fore and Aft Stowage)	Remarks
1	1-140-Ton Crane	4		One crane is preloaded into three LCM8s.
(1)	3-LCM8	12		Contains the 140-ton crane pre-loads.
2	1-250-Ton Crane Carrier	7		Pre-loaded in an LCM8.
(2)	1-LCM8	12		Contains pre-loaded 250-ton crane carrier.
3	4-Causeway Sections (3x15)	15		Stacking calculated for only one high and three across. Test load may be only two across as preferred. One causeway section is a warping tug. These items may be off-loaded as part of Solid Shield 76.
4	1-LACV-30	6		Use of LACV-30 as a test item subject to results of manufacturer's loading procedures study.
	2-LCM6 Tender Boats 1-30-Ton Crane	27 –		Solid Shield 76 Equipment.
5	1-Toplift Loader	64	(No illustrations are attempted since the number of these items to be test loaded will not materially influence the ship's overall capacity and a trade-off analysis is not, therefore, required.)	LOTS Equipment
6	1-Sideloader	48		LOTS Equipment
	1-20-Ton Truck Crane	32		Helps in 140-ton crane assembly. A 30-ton mobile crane will also be loaded having approximately the same dimensions as part of the Solid Shield 76 exercise equipment.

1/ Capacity is based on the estimated exclusive loading of only one type item. A sample mixed load is indicated by the cross-hatched area.

2/ Weather deck stowage is divided by machinery spaces amidship.

FIGURE 18. ILLUSTRATION OF C981 LASH CAPACITIES FOR SELECTED LOTS HEAVY EQUIPMENT DEPLOYMENT (Includes Solid Shield 76 Proposed Equipment Load)

Loading and Unloading Procedures

Since the phase one equipment must be unloaded first, it should be loaded last. Figure 19 is an illustrative approach to the weather deck positioning of the proposed C981 LASH load. The two smaller cranes are positioned on-deck, but conceivably, they could be stowed on top of the causeway sections or the causeway sections could be stacked if there were a shortage of deck space. In the event a modified C881 is available an approach, as illustrated in Figure 20, could be used.

For the phase one unloading, equipment was sequenced so that the LACV-30 (the largest item) would be first off, the 140-ton crane and its components next, the 250-ton carrier (the heaviest item) was next, and the 20-ton crane (whicn requires lighterage that was previously unloaded) last. For the phase two unloading, equipment was sequenced so that the tender boats and warping tug would be the first off, while the 30-ton crane (which will be loaded onto lighterage) is last.

The recommended sequence for loading is:

Phase Two

1. 30-ton rough terrain crane
2. 3 x 15 causeway[8/]
3. 3 x 15 causeway[8/]
4. 3 x 15 causeway[8/]
5. Warping tug (3 x 15)[8/]
6. Two LCM6 Tender Boats

Phase One

7. Toplift Loader
8. Sideloader
9. 20-ton crane
10. One LCM8 preloaded with 250-ton crane carrier
11. Two LCM8s preloaded with 140-ton crane booms and counterweight
12. One LCM8 with 140-ton crane (tactical disassembly).

Both the LCM8 preloaded with the 140-ton crane (less boom sections and counterweight– 99.8 long tons) and the LCM8 preloaded with 250-ton crane carrier (112.3 long tons) exceed the asymmetric lift limitations and must be loaded using the center lifting point of the beam. The dual LCM8 lift assumes that all five boom sections (approximately seven long tons) are mobile-loaded on an M127A2C trailer (approximately six long tons) and the counterweight (approximately 18 long tons) is loaded on an M172A1 semi-trailer (approximately seven long tons). These items will constitute a symmetric lift of 162 long tons.

The LACV-30 is the last item proposed for the LASH pretest. Its inclusion is contingent upon the availability of an adequate lift beam or suitable rigging procedures. It will probably have to be loaded stern first since its center of gravity is closer to the aft end. The major problem in loading the LACV-30 is thought to be the height of the craft and the clearance of the ship's upper deck. The LACV-30 manufacturer has been queried regarding procedures which can be used to load this vehicle.

[8/] It is possible that lifts two and three could be loaded simultaneously, as could lifts four and five.

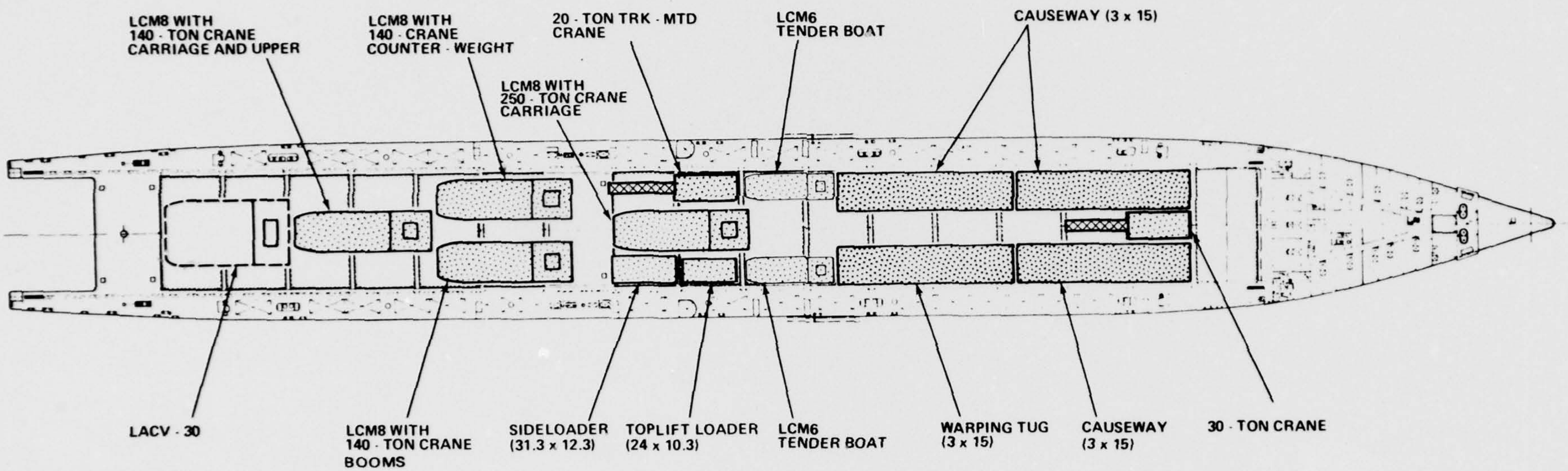


FIGURE 19. C981 LASH PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT

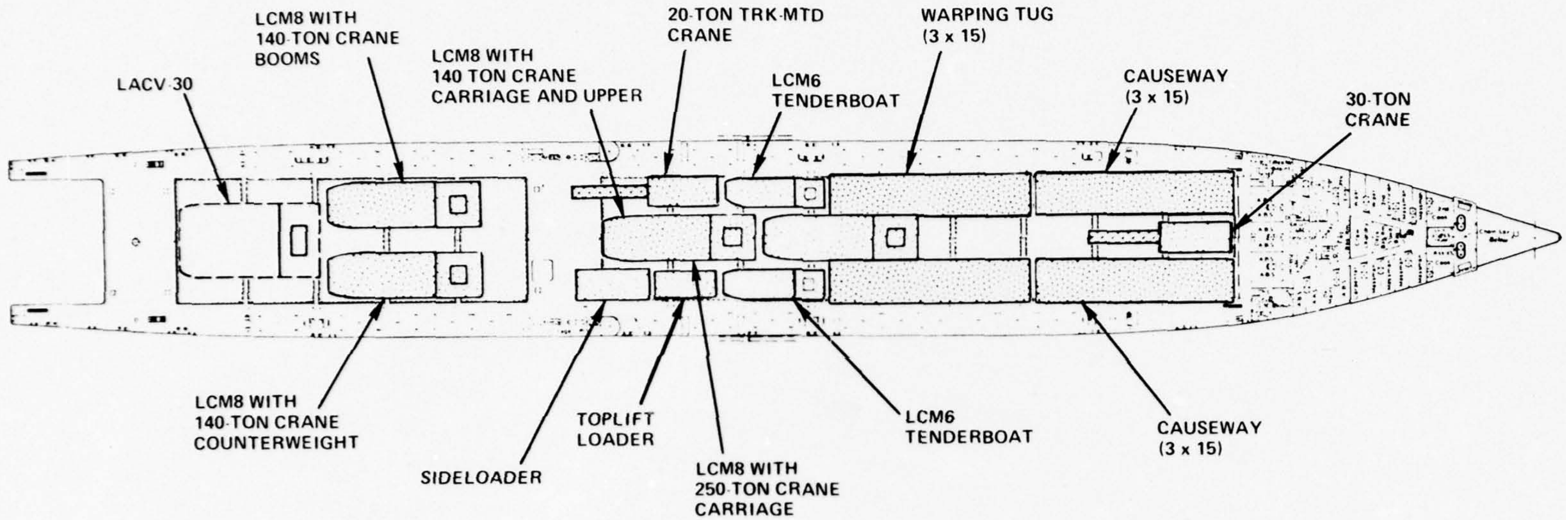


FIGURE 20. C881 LASH PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT

SEABEE

Pretest Description

The largest and heaviest LOTS equipment to be loaded and unloaded in the pretesting phase will be accomplished using the SEABEE. Equipment to be loaded on the upper (weather) deck will be an LCU, LACV-30, and a DeLong "B" Barge. Below decks (on the main deck) equipment to be loaded will include an LCM8, 3 x 15 causeway section, and a LARC-LX. This pretest will be the only one in which the 250-ton crane will be deployed in a near ready-for-use configuration. All loads will require careful planning and shoring to ensure interface between the equipment being loaded and the ship's barge transporters.

Rationale

In the absence of a self-propelled container discharge facility or one which is hull-mounted for rapid deployment, it is desirable to find an alternative to prepositioning or the slow process of towing floating cranes or heavy barges to an objective area. If the SEABEE is potentially capable of providing a 20-knot deployment solution, this option and its constraints need to be evaluated.

The SEABEE is potentially the only ship capable of deploying all LOTS system equipment, including the DeLong "B". Although there are only three SEABEE ships in service, their unique military capabilities make them an important element of the LOTS deployment evaluation. (See *Figure 21* for selected LOTS equipment capacity.)

Loading and Unloading Procedures

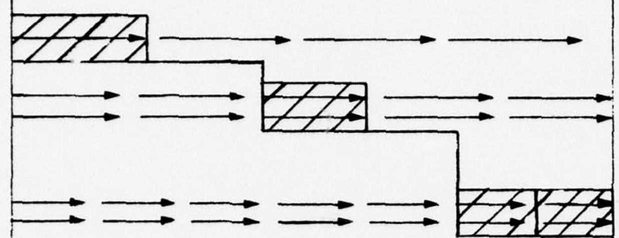
The equipment for test loading and relative positioning are depicted in Figure 22. All equipment must be compatible with or adapted to accommodate the SEABEE barge transporters and elevator. Equipment to be loaded must be positioned on the ship's elevator so that it can interface with the barge transporters for movement and stowage.

The heaviest test equipment is to be loaded on the SEABEE upper deck. The first item to be loaded is an LCU, which is approximately 17 feet longer than the elevator. This lift is nearly the same width (four feet narrower) as the SEABEE barge. Because of the irregular, curved configuration of the LCU's bottom, interface with the barge transporter may require use of an adaptive device. The SEABEE's container adapter[9/] might serve such a function. The second lift, a LACV-30, is also narrower than a SEABEE barge but should be easier to load than an LCU.

The third lift is the DeLong "B" (weight is 650 long tons "bare" and it is 48 feet longer than the elevator). A P&H 6250 (158 long tons) will be positioned on the DeLong for concurrent loading.

[9/] The SEABEE container adapter is half the length of a barge and fits on the upper deck barge support rails. It is used as an interface for the stowage of containers on the upper deck.

EQUIPMENT LOADING OPTIONS
SEABEE
(Includes Upper and Main Decks)

Test Priority	Equipment to be Test Loaded	Single Item Capacity*	Stowage Utilization Comparison	Remarks
				UPPER DECK
1	1-DeLong "B" Barge	4		Will have 250-ton crane aboard.
4	1-LCU (1466-Class)	10		Class LCU employed is not critical to ship loading.
	1-LACV-30	14		Optional test item.
2	1-250-Ton Crane (assembled)	–		Preload crane on DeLong.
				MAIN DECK
3	1-Causeway (3x15)	45	(No illustrations are attempted since test loads do not approach the capacity of either of these stowage spaces and no trade-off analyses are required to accommodate test loads.)	Calculated for stacking only one high.
	1-LCM8	50		Optional test item.
	1-LARC-LX	58		Optional test item.

* Capacity is based on the estimated exclusive loading of only one type item. A sample mixed load is indicated by the cross-hatched area. The capacities for the causeway, LCM8 and LARC-LX include all three stowage levels.

FIGURE 21. ILLUSTRATION OF SEABEE SHIP CAPACITIES FOR SELECTED LOTS HEAVY EQUIPMENT DEPLOYMENT

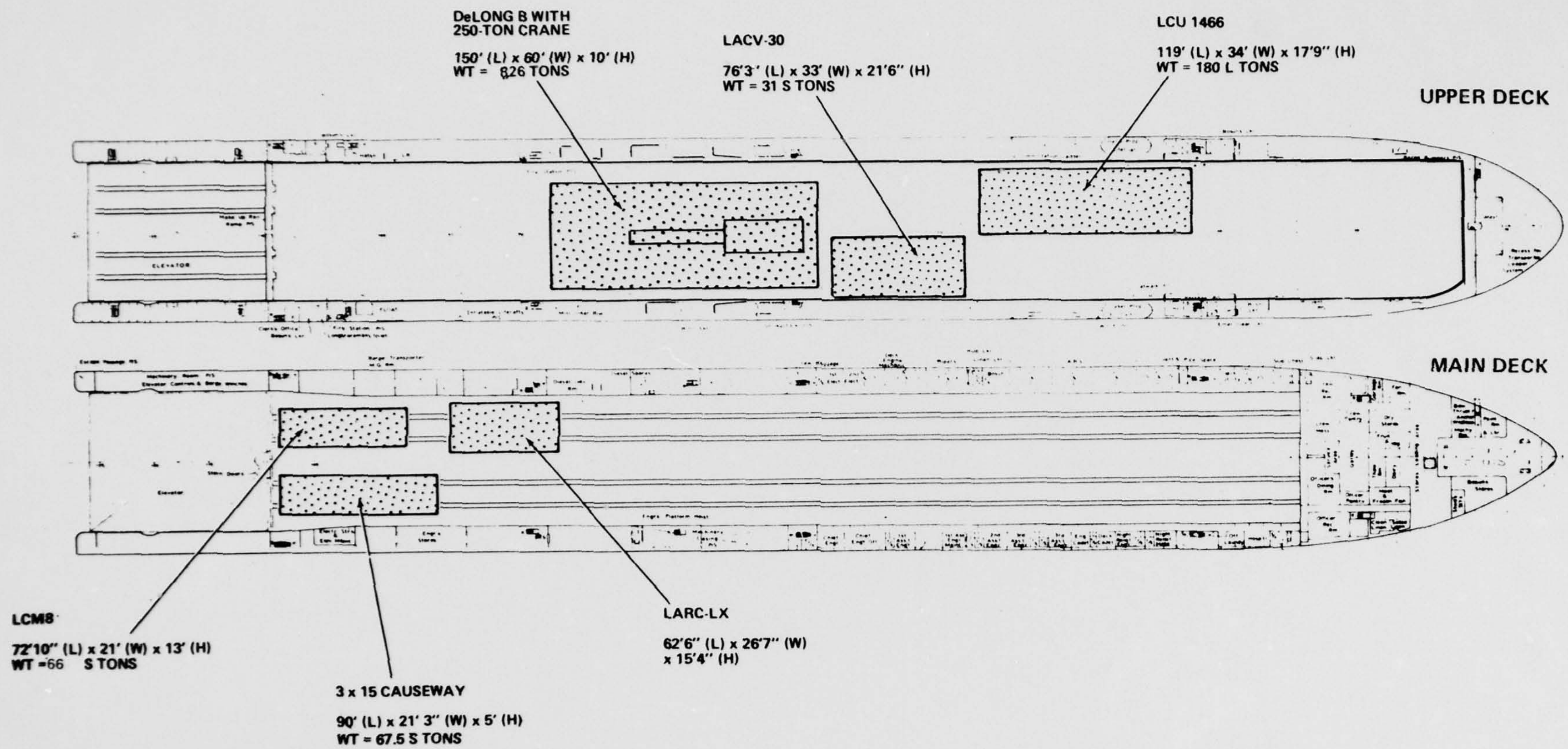


FIGURE 22. SEABEE PRETEST LOADING PLAN FOR SELECTED LOTS HEAVY EQUIPMENT

The below deck loading, which could be accomplished on either the main or lower deck, involves a LARC-LX which can be driven directly from the elevator onto the main deck (see Figure 23) for stowage; a 250-ton crane (discussed above); an LCM8; and a 3 x 15 causeway section.

Both the causeway section and the LCM8 can be loaded simultaneously. These lifts are similar in that neither is wide enough to rest on the ship's barge pedestals. This problem could be alleviated by canting the equipment on the elevator so they are moved and stowed at a slight diagonal to the barge transporter and barge pedestals. Another method would be shoring (using timbers) beneath the LCM8 and causeway so that the support extends across the pedestals beneath the causeway and LCM8.[10/]

[10/] The Navy has an on-going study project aimed at verifying the feasibility and techniques for loading certain LOTS components including the DeLong "B" Barge aboard a SEABEE. Subject to sponsor approval, the basic concepts outlined in this study could provide guidance for conduct of the LOTS test lifts. Also, the proposed modification and adapters recommended in the study might be refined to provide specifications for their timely installation/fabrication.

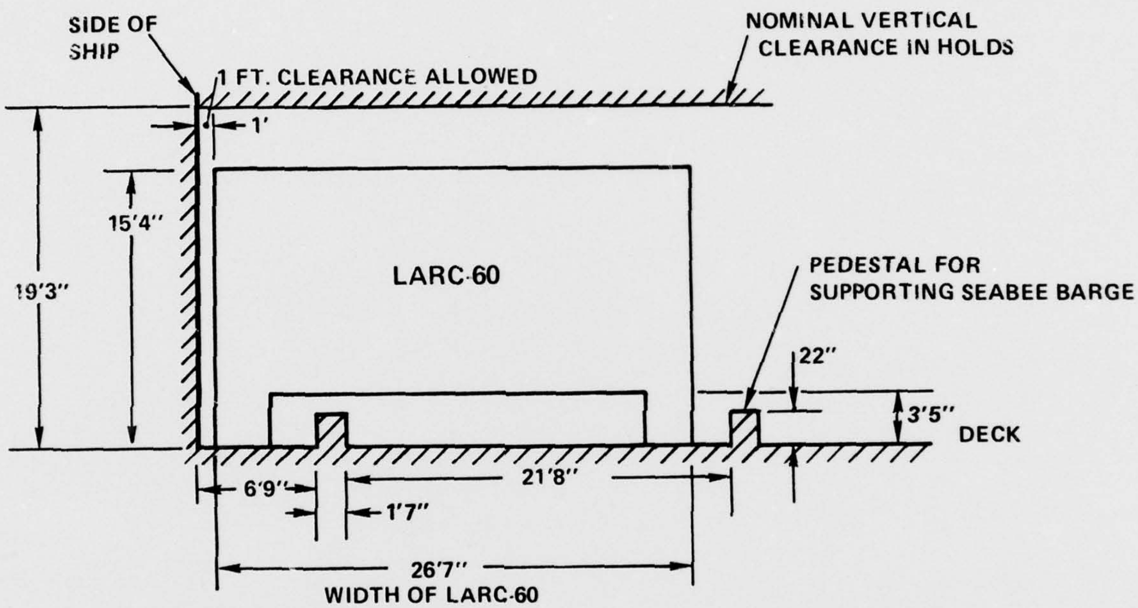


FIGURE 23. SKETCH OF LARC-LX IN HOLD OF SEABEE SHIP
(either port or starboard side)

E. PROCEDURES IN PRETEST CONDUCT

This section of the report outlines some of the procedures that apply to pretest conduct. They are provided primarily to highlight some concepts and guidelines that are unique to the pretest experiments.

While the main LOTS field test is to be conducted under criteria and conditions that are as representative as possible of a realistic operational environment, this is not generally true of the pretest events. Their main purpose is to technically validate and fix main test concepts and conditions and to provide a basis for further evaluation. They are not intended as a test of unit readiness, levels of proficiency, or speed in accomplishing prescribed events.

As discussed previously, the main objective of the ship-equipment pretests is to verify by physical demonstration under controlled and semi-controlled conditions, the capabilities related to deploying selected LOTS system equipment in merchant ships. These demonstrations involve:

- Operations with combinations of equipment, ships and techniques with which there is little or no practical experience
- Employment of high-cost test equipment and services in a risk environment and on a restrictive time schedule.

For the above reasons, the conduct of the pretests should consider the following:

- Employing the most highly skilled and experienced military personnel for equipment operation, stevedoring and longshoreman functions.

- Pre-positioning test loads and all test support items at the test site to make maximum use of ship charter time. When possible, pre-installation of instrumentation should be accomplished. The conduct of the pretest is not scenario-constrained (as the main test will be) thus requirements such as site preparation for crane beaching and assembly may be accomplished administratively in advance of actual test events.

- Providing for an adequate, reliable voice communication capability at the pretest site (including ship-to-shore) to ensure positive control and coordination of all test activity.

- Making maximum use of military owned/controlled facilities for all pretest operations. This should present no major problem when MSC-controlled fleet ships are employed or when dedicated commercial charters can be made available at military pier facilities. If it is necessary to resort to partial and/or concurrent use of a test ship berthed at a commercial facility, operational test planning should attempt to minimize use of commercial equipment or services (e.g., use of military floating crane for containership pretest loading).

- Conducting thorough pretest training and orientation. While main test concepts envision some "free play" in areas of management decisions and unit procedures, pretest objectives and schedules dictate a more controlled approach. Test operating personnel should not only possess requisite technical proficiency, but must be thoroughly oriented on details of test conduct. Special areas of emphasis should include a complete understanding of the chain of command during all phases of test conduct and familiarity with the pretest site and facilities. Where distances and size of test force are not prohibitive, orientation visits are recommended to acquaint test personnel with site layout, procedures, and physical and administrative limitations.

- Providing for contingency alternatives in operational test planning and directives. The very nature of the LOTS pretests presents a formidable challenge in the requirement to anticipate and provide the flexibility to cope with a variety of test contingencies without excessive commitment of resources. Some critical areas that merit special attention include:

    - Ship and equipment substitution as to both type and time of availability

    - Malfunction of ships booms, elevators or cranes

- Malfunction of craft/lighters in ship-to-shore subtests
- Malfunction of test instrumentation equipment
- Administrative limitations imposed on test operations, such as temporarily derated cargo gear (booms, elevators, etc.), prohibitions on off-shore discharge, regulatory agency restrictions, etc.
- Emergency absence of key test personnel
- Delays or interruptions due to weather or sea conditions.

It is impractical to attempt to prescribe general solutions, although some fundamental considerations should include:

- Providing for major test alternatives (e.g., modifying ship-equipment combinations) early in the operational planning phase. As a matter of general policy, alternatives, whether in the planning phase or during test execution, should have as their goal the acquisition of maximum test data. Provision for modified events or substitute equipment can usually provide data that will serve as a basis for extrapolation and is generally preferable to a complete test abort.
- Careful formulation and specific understanding of ship charter provisions.
- Within funding limits, providing for alternate test loads (e.g., weighted equipment mock-ups), back-up landing craft at off-shore discharge sites, extra sets of slings, rigging and chocking material, trained back-up test crews, stand-by heavy maintenance teams, etc.
- Providing for long- and short-range weather and sea condition forecasts.

APPENDIX A

SHIP SUITABILITY AND AVAILABILITY

SUITABILITY

The United States currently has the largest fleet of intermodal ships in the world. This fleet consists of 91 active non-self-sustaining (NSS) containerships, 22 self-sustaining (SS) containerships, 23 barge carriers, 13 vehicle (roll-on/roll-off or "RO/RO") carriers, 5 combination container and RO/RO ships[1/], and 46 partial containerships[2/]. In addition to the intermodal ships there are 115 breakbulk ships in service. Both the intermodal and breakbulk ships constitute the resources from which the LOTS ship resources will be drawn.

The basic approach to ship analysis was the identification of cargo fleet assets (less bulk carriers), assimilation of certain basic operational and cargo characteristics, cataloging of ships by type and hull designation, and review of various ship plans and drawings for detailed information. This data is contained in Tables A.1 through A.9 and Figure A.1. To help draw a

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[1/] Several vessels have capacities for both containers and vehicles. Those cases in which the vehicle capacity is relatively small, however, are included only in the containership category.

[2/] According to the U. S. Maritime Administration's strict definition, only those general cargo ships that have one or more of their holds permanently fitted with cellular structures are considered partial containerships. By this strict definition only 22 ships could be considered partial containerships. The Military Sealift Command has broadened this category to include all ships which have pre-installed container cells regardless of whether all or part of one hold (or several) may be involved. The container capacities of these ships are given in Table A.5.

statistical profile of a representative NSS containership certain ship characteristics were highlighted and summarized. The results of that summarization are contained in Table A.3.

The common denominator used for grouping and cataloging ships was the hull designation. Because the merchant dry cargo fleet includes approximately 302 vessels of some 83 different hull designs, each having different capabilities and limitations, and because of frequent changes in ship names, ownership, routes, etc. it is preferable to group the ships by type (breakbulk, RO/RO, etc.) and then, by hull designation[3/] within each type. Differences between ships of a particular hull designation (there may be as many as 13 vessels or as few as one within a group) are often inconsequential, but where there are noteworthy exceptions such as boom capabilities, the exceptions were noted and the ship was considered separately.

AVAILABILITY

A second phase of the analysis consisted of a review of the ships available under the Sealift Readiness Program (SRP) to assess the characteristics and capabilities of ships and the time table for their availability. This analysis (Table A.10) was used to provide a general profile of the abilities and requirements of merchant ships to support LOTS operations if the SRP were ever to be implemented.

PREFERENCE

Matrices were developed (Tables A.11 to A.12) to evaluate both the containerships and the breakbulk ships based on the operational and test criteria applicable in each case. Weighting factors used in the evaluation are explained in each table. Because the Military Sealift Command possesses sufficient and suitable assets to support potential LOTS test requirements, no analyses were necessary for RO/RO ships.

[3/] Normally a hull designation such as C6-S-85b is used by MARAD. This is frequently abbreviated to C685, for example. Privately financed hulls are referred to by a private designator, such as SL-7, or listed as undesignated.

TABLE A.1

NON-SELF-SUSTAINING CONTAINERSHIPS, BY HULL AND OWNER/OPERATOR

C2X
1. AFOUNDRIA (SL)
2. ARIZPA (SL)
3. WACOSTA (SL)
4. WARRIOR (SL)

XT 2E
5. TRANSCHAMPLAIN (Mat) (CIT Corp)
6. TRANSONEIDA (Mat) (CIT Corp)
7. TRANSONTARIO (Mat) (CIT Corp)

T2M
8. HOUSTON
9. JACKSONVILLE (SL)
10. TAMPA (SL)

T2/C4
11. ANCHORAGE (SL)
12. BALTIMORE (SL)
13. SEATTLE (SL)

EXC3
14. HAWAIIAN CITIZEN (Mat)

EXC4
15. GUAM BEAR (PFEL)
16. HAWAII BEAR (PFEL)
17. CALIFORNIAN (Mat)
18. HAWAIIAN (Mat)
19. HAWAIIAN MONARCH (Mat)
20. HAWAIIAN QUEEN (Mat)
21. AQUADILLA (TRANSHAWAII) (PRMSA)
22. CAROLINE (TRANSIDAHO) (PRMSA)
23. TRANSINDIANA (ST) (HWC)
24. MAYAGUEZ (TRANSOREGON) (PRMSA)

C4J
25. LONG BEACH (SL)
26. OAKLAND (SL)
27. PANAMA (SL)
28. BORINQUEN (TRENTON-SL) (PRMSA)

C4J1
29. SAN JUAN (CHICAGO) (PRMSA)
30. ARACIBO (ROSE CITY) (PRMSA)

C4X
31. BOSTON (SL)
32. HUMACAO (BROOKLYN) (PRMSA)
33. CHARLESTON (SL)
34. GALVESTON (SL)
35. MOBILE (SL)
36. GUAYAMA (NEW ORLEANS) (PRMSA)
37. NEWARK (SL)
38. PHILADELPHIA (SL)
39. PORTLAND (SL)

C573
40. C V LIGHTNING (AEL)
41. C V STAG HOUND (AEL)
42. EXPORT FREEDOM (AEL)
43. EXPORT LEADER (AEL)
44. EXPORT PATRIOT (AEL)

C61W
45. AMERICAN ACCORD (USL)
46. AMERICAN ACE (USL)
47. AMERICAN ALLIANCE (USL)
48. AMERICAN ARCHER (USL)
49. AMERICAN ARGOSY (USL)
50. AMERICAN LEADER (USL)
51. AMERICAN LEGACY (USL)
52. AMERICAN LEGEND (USL)

C61X
53. PRESIDENT TRUMAN (JAPAN MAIL) (APL)
54. PRESIDENT KENNEDY (OREGON MAIL) (APL)
55. PRESIDENT EISNEHOWER (PHILLIPINE MAIL) (APL)
56. PRESIDENT ROOSEVELT (WASHINGTON MAIL) (APL)

C669
57. PRESIDENT FILLMORE (APL)
58. PRESIDENT GRANT (APL)
59. PRESIDENT McKINLEY (APL)
60. PRESIDENT TAFT (APL)
61. PRESIDENT VAN BUREN (APL)

C685
62. AUSTRAL ENDURANCE (FL)
63. AUSTRAL ENSIGN (FL)
64. AUSTRAL ENTENTE (FL)
65. AUSTRAL ENVOY (FL)
66. PRESIDENT JEFFERSON (APL)
67. PRESIDENT JOHNSON (APL)
68. PRESIDENT MADISON (APL)
69. PRESIDENT PIERCE (APL)

C768
70. AMERICAN APOLLO (USL)
71. AMERICAN AQUARIUS (USL)
72. AMERICAN ASTRONAUT (USL)
73. AMERICAN LANCER (USL)
74. AMERICAN LARK (USL)
75. AMERICAN LEGION (USL)
76. AMERICAN LIBERTY (USL)
77. AMERICAN LYNX (USL)

SL-7
78. SEA-LAND COMMERCE (SL)
79. SEA-LAND EXCHANGE (SL)
80. SEA-LAND FINANCE (SL)
81. SEA-LAND GALLOWAY (SL)
82. SEA-LAND MARKET (SL)
83. SEA-LAND MCLEAN (SL)
84. SEA-LAND RESOURCE (SL)
85. SEA-LAND TRADE (SL)

C788
86. SEA-LAND CONSUMER (SL)
87. SEA-LAND PRODUCER (SL)

SL-18
88. SEA-LAND ECONOMY (SL)
89. SEA-LAND VENTURE (SL)

Non-Desig
90. HAWAIIAN ENTERPRISE (Mat)
91. HAWAIIAN PROGRESS (Mat)

KEY

AEL - American Export Lines Inc.
APL - American President Lines
CIT Corp - C. I. T. Corporation
FL - Farrell Lines, Inc.
HWC - Hudson Waterways Corp.
Mat - Matson Navigation Co.
PFEL - Pacific Far East Line
PRMSA - Puerto Rico Maritime Shipping Authority
SL - Sea-Land Services, Inc.
ST - Seatrain Lines, Inc.
USL - United States Lines

TABLE A.2

U. S. FLAG NON-SELF-SUSTAINING CONTAINERSHIP CHARACTERISTICS SUMMARY

Shipping Category	Hull Type	Qty Ships	Operator/ Owner	Container Capacity	Container Size	Year Built	Number Hatches	Speed	Remarks
Non-Self-Sustaining Containership	C2X	4	SL	225-35'	35	1943-44	4Fwd,3Aft	15.5	Converted 1965-66
	XT2E	3	Mat	606-20'	27&40	1944-45	7Fwd	16.0	40' slots = 303; 27' slots = 435; converted 1969
	T2M	3	SL	332-35'	35&40	1944	8Fwd	16.0	onverted 1967-69; Tampa partially obstructed
	T2/C4	3	SL	354-35'	35&40	1943-44	8Fwd	14.5	Converted 1969-70; Deck partially obstructed
	EXC3	1	Mat	488-24'	24	1944	3Fwd,2Aft	16.5	
	C4J	3 1	SL PRMSA	609-35'	35&40	1944-45	11Fwd,1Aft	17.0	Converted 1966; Deck obstructions outbd sides
	C4J1	2	PRMSA	622-35'	35&40	1944-45	11Fwd,1Aft	17.0	Converted 1969; Deck obstructions on centerline
	C4X	7 2	SL PRMSA	360-35'	35&40	1944-45	7Fwd	17.0	Converted 1968-69; additional on-deck stowage fore and aft
	EXC4	2	PFEL	544-20'	20&40	1943&45	8	17.0	Have capacity for 25 vehs
		2	Mat	(2)527-24'	24&40	1946	11	16.8	2 ships carry sugar; 2 ships carry 193 vehs; 40' slots = 24.
		2		(2)805-20'	24&40	1944	11	17.0	
		3 1	PRMSA ST	962-20'	40	1944-45	8Fwd	17.0	40' slots = 482; one additional stow space on deck
	C573	5	AEL	1,076-20'	20	1969-73	14Fwd,2Aft	20.0	Minor stowage Aft
	C61W	8	USL	1,009-20'	20&40	1953-54	14Fwd,9Aft	20.0	40' slots = 466 or 484 depending upon ship
	C61X	4	APL	894-20'	20&40	1961-64	14Fwd,9Aft	20.0	40' slots = 269
	C669	5	APL	1,066-20'	20&40	1967-68	18Fwd,5Aft	23.0	40' slots = 414
	Non-desig	2	Mat	1,168-24'	24&40	1970	13 Amidship	23.0	40' slots = 44; partial obstructions amidship C/L
	C685	4 4	FLI APL	1,100-20' 1,180-20'	20&40 20&40	1972-73 1973-74	28Fwd,4Aft	22.6 23.0	Has 201,460 bale cube and 70-T and 30-T booms for unitized cargo besides container cargo.
	C768	8	USL	(2)1,258-20' (4)1,292-20' (2)1,330-20'	20&40	1968-69	22Fwd,6Aft	22.5	40' slots = 498
	SL-18	2	SL	759-35'	35&40	1970-71	1Fwd,10Amidship	23.0	40' slots = 181; 35' = 552; obstructions outbd
	SL-7	8	SL	1,096-35'	35&40	1972-73	24Amidship, 15Aft	33.0	40' slots = 326, partial obstructions
	C788	2	SL	759-35'	35&40	1970-71	1Fwd,10Amidship	23.0	40' slots = 181; 35' = 552

TABLE A.3

GENERAL CHARACTERISTICS NON-SELF-SUSTAINING CONTAINERSHIPS

			Number MERSHIPS	MERFLEET Representation
CONTAINER CAPACITY:				
Less than 600 (20' equivalent) containers			24	26%
600-899 (20' equivalent) containers			12	13%
More than 900 (20' equivalent) containers			55	61%
CONTAINER CELL SIZES AND AVERAGE CAPACITY:				
20' cell ships (with limited 40' stowage) (mean average is 943 20' containers with standard deviation of 225)			40	45%
24' cell ships (with limited 40' stowage) (mean average is 788 24' containers with standard deviation of 271)			7	8%
35' cell ships (with limited 40' stowage) (mean average is 586 35' containers with standard deviation of 309)			37	39%
40' cell ships (mean average is 404 40' containers with standard deviation of 90)			7	8%
SHIP SPEEDS:				
< 15 knots			3	3%
15 - 16.9 knots			15	16%
17 - 18.9 knots			24	26%
19 - 20.9 knots			17	19%
21 - 22.9 knots			9	10%
23 - 24.9 knots			15	16%
> 25 knots			8	9%
OWNERS/OPERATORS:	Area of Operation	Subsidized		
American Export Lines	(Atl/Gulf)	Yes	5	5%
American Presidents Line	(Pacific)	Yes	13	14%
Farrell Lines Inc.	(Atl/Gulf to Pac)	Yes	4	4%
Matson Navigation	(Pacific)	No	7	8%
Pacific Far East Lines	(Pacific)	Yes	2	2%
Puertico Rico Maritime Shipping Authority	(Atl/Gulf)	No	8	9%
Sea-Land	(Both)	No	31	34%
Seatrain	(Both)	No	4	4%
United States Lines	(Both)	No	16	18%
CARGO HATCHES:		Number Hatches		
Overall Average Number Hatches Per Ship (Standard Deviation of 10.6)		9		
Number Ships with Superstructure Separating Holds				
Major Division (>1/3 of holds aft of superstructure)			24	26%
Minor Division (<1/3 of holds aft of superstructure)			38	42%
No Divisions (but minor on-deck obstructions included)			29	32%

TABLE A.4

PARTIAL SELF-SUSTAINING CONTAINERSHIPS BY HULL AND OWNER/OPERATOR

C346

1. EXPORT CHALLENGER (AEL)
2. EXPORT CHAMPION (AEL)

C410

3. PRESIDENT LINCOLN (APL)
4. PRESIDENT TYLER (APL)

C449

5. SANTA MAGDALENA (P-G)
6. SANTA MARIA (P-G)
7. SANTA MARIANA (P-G)
8. SANTA MERCEDES (P-G)

C460

9. MORMACALTAIR (MM)
10. MORMACARGO (MM)
11. MORMACDRACO (MM)
12. MORMACLYNX (MM)
13. MORMACRIGEL (MM)
14. MORMACVEGA (MM)

C464

15. AMERICAN RANGER (USL)
16. AUSTRAL PATRIOT (FLI)
17. AUSTRAL PILOT (FLI)

C465

18. SANTA BARBARA (P-G)
19. SANTA CLARA (P-G)
20. SANTA CRUZ (P-G)
21. SANTA ELENA (P-G)
22. SANTA ISABEL (P-G)
23. SANTA LUCIA (P-G)

C469

24. COLORADO (SSC)
25. IDAHO (SSC)
26. MICHIGAN (SSC)
27. MONTANA (SSC)
28. WYOMING (SSC)

C537

29. ASHLEY LYKES (LL)
30. BRINTON LYKES (LL)
31. JAMES LYKES (LL)
32. JEAN LYKES (LL)
33. JOHN LYKES (LL)
34. JOSEPH LYKES (LL)
35. LESLIE LYKES (LL)
36. MARJORIE LYKES (LL)
37. NANCY LYKES (LL)
38. SHIRLEY LYKES (LL)
39. SOLON TURMAN (LL)
40. THOMPSON LYKES (LL)
41. ZOELLA LYKES (LL)

C575

42. ALASKAN MAIL (APL)
43. AMERICAN MAIL (APL)
44. HONG KONG MAIL (APL)
45. INDIAN MAIL (APL)
46. KOREAN MAIL (APL)

SELF-SUSTAINING CONTAINERSHIPS BY HULL AND OWNER/OPERATOR

C2C

1. AZALEA CITY (SL)
2. BEAUREGARD (SL)
3. BIENVILLE (SL)
4. FAIRLAND (SL)
5. GATEWAY CITY (SL)
6. RAPHAEL SEMMES (SL)

C2L

7. MAYAGUEZ (SL)
8. PONCE (SL)

EXT2

9. SUMMIT (SL)

T3-J

10. ELIZABETH PORT (SL)
11. LOS ANGELES (SL)
12. SAN FRANCISCO (SL)
13. SAN JUAN (SL)

C346

14. EXPORT COMMERCE (AEL)
15. EXPORT COURIER (AEL)

C4JC

16. PITTSBURG (SL)
17. SAN PEDRO (SL)
18. ST. LOUIS (SL)

EXC4

19. HAWAIIAN PRINCESS (Mat)

C6QC

20. PRESIDENT HARRISON (APL)
21. PRESIDENT MONROE (APL)
22. PRESIDENT POLK (APL)

KEY

AEL - American Export Lines
APL - American President Lines
FLI - Farrell Lines, Inc.
LL - Lykes Brothers Steamship Co. (Lykes Lines)
Mat - Matson Navigation Co.
MM - Moore-McCormack Lines, Inc.
P-G - Prudential-Grace Lines, Inc.
SL - Sea-Land Services, Inc.
SSC - States Steamship Co.
USL - United States Lines, Inc.

TABLE A.5

U.S. FLAG SELF-SUSTAINING AND PARTIAL CONTAINERSHIP CHARACTERISTICS SUMMARY

Ship Category	Hull Type	Qty Ships	Owner-ship	Container Capacity	Container Size	Year Built	Number Hatches(LxW in ft.)	Speed	Remarks
Self-Sustaining Container-ships	C2C	6	SL	226-35'	35'	1942-43	4fwd, 3aft	15.5	2 26-Ton Gantry cranes
	C2L	2	SL	274-35'	35&40	1944	5fwd, 3aft	15.0	2 22-Ton Gantry cranes
	EXT2	1	SL	226-35'	35'	1943	7fwd	14.5	2 Gantry cranes
	T3J	4	SL	476-35'	35&40	1941-42	10fwd	15.5	2 25-Ton Gantry cranes
	C346	2	A.E.L.	440-20'	20&40	1962-63	6--42.5,40,37.5, 30,20,3x28	18.5	60-Ton Max boom cap. 116 40-foot slots
	EXC4	1	Mat.	350-24'	24&40	1946	7 (3 holds)-- 24.5x43.5	17.0	50-Ton Max boom cap.; 25 40-foot slots; also has capacity for 457 autos
	C4JC	3	SL	602-35'	35&40	1942-44	11fwd	17.0	2 22-Ton Gantry cranes. Additional on deck stowage aft.
	C6QC	3	A.P.L.	792-20'	20&40	1965-66	17 (8 holds)--14.5, 41,25,20.2x26.2	20.0	60-Ton Max boom cap. 387 40-foot slots
Partial Container-ships, Self-Sus-tain	C346	4	A.E.L.	468-20'	20&40	1963	6--40,30, 20.2x31	18.5	60-Ton Max boom cap.; 116 40-foot Cntr slots avail.; see self-sustain
	C41Q	2	A.P.L.	481-20'	20&40	1961	20 (7 holds)-- 30,25,22,21.5,20.5 10x26	20.0	30-Ton Max boom cap. 74 40-foot Cntr slots avail.
	C449	4	P-G.	351-20'	20&40	1963-64	13 (5 holds)-- 23.9,20.4, 19.9x42.1	20.0	40-Ton Gantry cranes 44 40-foot Cntnr slots avail.
	C460	6	M-Mc	200-20'	20&40	1964-65	12 (6 holds)-- 44.6,42.1,40.7, 24.3,23.7x24.6	21.0	75-Ton Max boom cap. 50 40-foot slots
	C464	3 2	U.S.L. F.L.I.	70-20' 166-20'	20 20	1964-65 1965	10 (6 holds)-- 42,32,30x30	21.0	70-Ton Max boom cap.
	C465	7	P-G.			1966-67	9 (7 holds)-- 42.5,35,30,27.5, 24.8x28	20.0	Six ships have 80-Ton Max boom cap. One ship has 150-Ton BM capability.
	C469	5	S.S.C.	230-20'	20&40	1968-69	13 (7 holds)--37.5, 18,15.5x22	23.0	60-Ton Max boom cap. 16 40-foot slots
	C537	13	L.L.	266-20'	20	1960-63	6--39.9,34.9, 31.2,29.9x24.9	17.4	60-Ton Max boom cap.
	C575	5	A.P.L.	387-20'	20&40	1968-69	7--42.5,35, 28.5,27.5x25.5	20.8	70-Ton Max boom cap. 78 40-foot slots

TABLE A.6

BARGESHIP CHARACTERISTICS

Shipping Category	Hull Type	Qty. Ships	Ownership	Container Capacity	Container Size	Year Built	Maximum Number Barges	Speed	Remarks (Crane cap. in L Tons)
Barge-Carrying Ships	C882 (SEABEE) C8-S-82a	3	LL	(On-deck) 320-20'	20 thru 40	1972-73	38	20.0	Containers in barges = 1,116 20-ft. equivalents; Container capacity w/out barges = 1,784 20' equivalent
	C881 (LASH) C8-S-81b	6	PFEL	534-20'	20 & 40	1971-74	50	22.5	Cntnr Gantry = 35T; Barge Gantry = 450T; Barge Cap. = 17,043 cu.ft. or 415ST; Container capacity variable s.t. trade-offs; Max container capacity = 1,200, no barges
		5	P-G	(1)534-20' (4)450-20'	20 & 40	1970-74	1-50 4-61	22.5	
	C981 (LASH) C9-S-81d	3	Delta	288-20'	20 & 40	1973	74	22.0	Barge Gantry = 510 Ton; Cntnr Gantry=35T
		3	WSS	-	-	1974	89	22.0	Barge Gantry = 446-Ton; No dedicated container stowage spaces or self-sustaining capability; Barge sizes = 61.5'x31'x13' and can accept cntnrs.
		3	C-G	-	-	1974-75	89	22.0	

BARGESHIPS BY HULL TYPE AND OWNER/OPERATOR

C881
LASH ITALIA (P-G)
AUSTRALIA BEAR (PFEL)
CHINA BEAR (PFEL)
GOLDEN BEAR (PFEL)
JAPAN BEAR (PFEL)
LASH ATLANTICO (P-G)
LASH ESPANA (P-G)
LASH PACIFICO (P-G)
LASH TURKIYE (P-G)
PACIFIC BEAR (PFEL)
THOMAS E. CUFFE (PFEL)

C882
DOCTOR LYKES (LB)
ALMERIA LYKES (LB)
TILLIE LYKES (LB)

C981
DELTA MAR (Delta)
DELTA NORTE (Delta)
DELTA SUD (Delta)
GREEN HARBOUR (C-G)
GREEN ISLAND (C-G)
GREEN VALLEY)C-G)
ROBERT E. LEE (WSS)
SAM HOUSTON (WSS)
STONEWALL JACKSON (WSS)

BARGE CHARACTERISTICS

	Hull Type	Qty	Ownership	External Size	Internal Size	Hatch Opening	Cube/WT Cap.	STon WT.	Cntnr Capacity	Remarks
Barges to Barge-Carrying Ships	LASH C-8	61	P-G	61.5'x31'x12'	59.75'x29.5'x10.1'	43.9'x29.4'	19,600/415	90	7-20' 3-40'	Cntnrs loaded internally only. Max allowable weight for lifting = 447STon
		50	PFEL	61.5'x31'x14.5'	59.75'x29.5'x10.1'	43.9'x29.4'	19,600/415	90	7-20' 3-40'	
	SEA-BEE	38	LL	97.5'x35'x12.5'	90'x32'x12.5'	84.9'x30.2'	40,000/954	188	14-20' 8-40'	Cntnrs loaded internally only
	LASH C-9	74	Delta, WSS, C-9	61.5'x31'x13'	59.75'x29.5'x10.1'	43.9'x29.4'	19,600/415	90	7-20' 3-10'	Cntnrs loaded internally only, Max allowable lifting WT-446ST

AD-A041 989 OPERATIONS RESEARCH INC SILVER SPRING MD F/G 15/5
DESIGN OF PRELIMINARY FIELD TESTS FOR THE LOGISTICS-OVER-THE-SH--ETC(U)
JAN 76 C COLLINS, G HOLIDAY, W SUTHERLAND MDA903-75-C-0016
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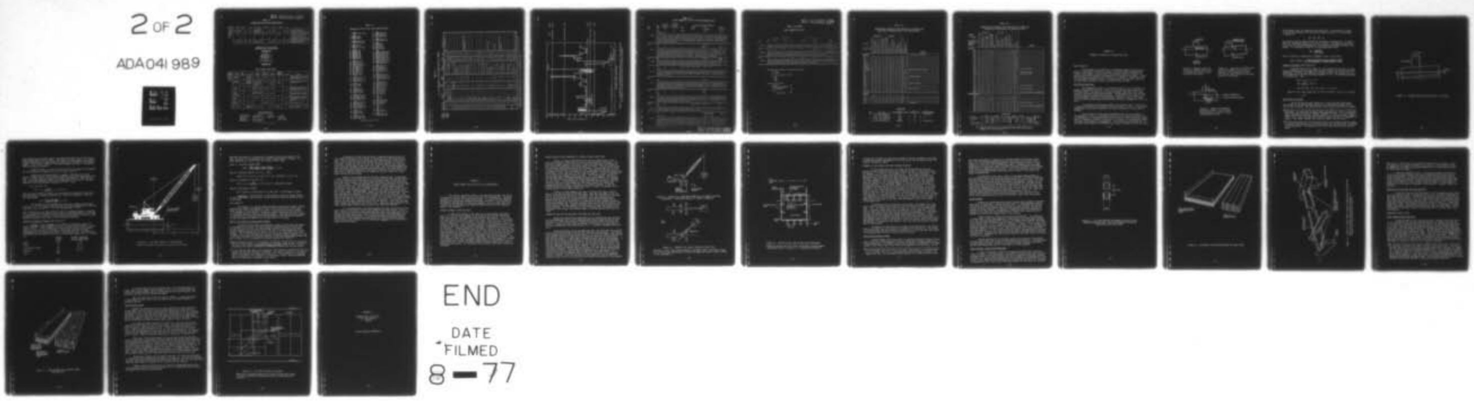

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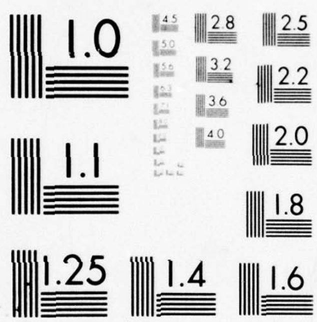

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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TABLE A.7

COMBINATION RO/RO AND CONTAINERSHIP

Shipping Category	Hull Type	Qty Ships	Ownership	Cargo Capacity	Square Ft. Capacity	Year Built	Vehicle Capacity	Speed	Remarks
Combination RO/RO Containership	New Yorker	1	SL	19-35'Cntnrs 29 chassis below deck		1960		16.0	MV type RO/RO with self-contained loading ramp.
	C578	4	AEL	810-20' Cntnrs	34,000	1969-70	Approx 220	23.6	Can handle 20' or 40' cntnrs; vehicle entry ports located at No. 7 hatch and at the stern. Size=15'x14.5';Max Boom capacity 70T;Ships are self-sustaining:2 ships operate E. Coast-Med,2 operate in Far East
	EXC4	1	Mat	350-24'Cntnrs		1946	452	17.0	50T max boom capacity; 25 40-foot container slots

COMBINATION RO/RO AND SELF-SUSTAINING
CONTAINERSHIP BY HULL AND OWNER/OPERATOR

Undesignated Hull
NEW YORKER (SL)

C578
DEFIANCE (AEL)
GREAT REPUBLIC (AEL)
RED JACKET (AEL)
YOUNG AMERICAN (AEL)

EXC4
HAWAIIAN LEGISLATOR (Mat)

Undesignated Hull
NEW YORKER (SL)

ROLL-ON/ROLL-OFF SHIPS

Shipping Category	Hull Type	Qty Ships	Ownership	Cargo Capacity	Square Ft. Capacity	Year Built	Vehicle Capacity (approx)	Speed	Remarks
Roll-on/Roll-off Ships	Callaghan Class	1	Sunexport Holdings	22,000M/T	167,000	1967	750	25	Max boom capacity = 120T; entry ramps on both sides and stern; booms can be married.
	Ponce de Leon Class	4	Puerto Rico Maritime Authority	40' Trlr Capacity varies from 241-278; also has vehicle cap.	157,000	1968-1975	450 (autos)	25	Entry via ramps positioned to starboard side.
		1	TTT			1974			
	Lurline Class	2	Mat	343-40' trlrs (plus 278 autos)	157,000	1973		24.0	Spar deck can be installed adding 108 more 40' trlr spaces has 3 side parts for entry
	C795 (Maine) C7-S-95a	1-4	SSC	386-40' Trlrs (plus 126 autos)	175,000	1975-76		23	Ships to be delivered in 1976. Container capacity is 822-20'.
	C3ST (Comet)	1	MSC	20,000 M/T	97,500	1958	700	18.0	Max boom capacity = 60T; fwd holds have capacity general cargo; entr
	C4ST (Sealift)	1	MSC		84,950	1967		20.0	Max boom capacity = 70T;
	GREAT LAND	1	Sunexport Holdings	390-40' Trlrs		1975	126 (autos)	24	This is a "jumboized" version of the Lurline Class.

ROLL-ON/ROLL-OFF SHIPS
BY HULL AND OWNER/OPERATOR

INDIVIDUAL CLASSES (One-of-a-kind)	PONCE-DE-LEON	LURLINE	MAINE
COMET (MSC)	PONCE-DE-LEON (PRMA)	LURLINE (Mat)	MAINE (SSC)
SEA LIFT (MSC)	ELTAINO (TTT)	MATSONIA (Mat)	(ARIZONA) (SSC)
CALLAGHAN (SH)*	ERIC K. HOLZER (PRMA)		(NEVADA)(SSC)
GREAT LAND (SH)	FORTALEZA (PRMA)		(ILLINOIS) (SSC)
	PUERTO RICO (PRMA)		

* Built for long-term charter to MSC

TABLE A.8

BREAKBULK SHIPS BY HULL AND OWNER/OPERATOR

C2A5
1. AMERICAN VICTORY (Victory)

C3A1
2. MARYMAR (Calmar)
3. PENNMAR (Calmar)
4. PORTMAR (Calmar)

C3A2
5. AMERICAN CONDOR (AFSC)
6. AMERICAN ORIOLE (AFSC)

C3A3
7. BROOK (AEL) (GNOC)
8. EXFORD (AEL)
9. SANTA INES (P-G) (GNOC)

C333
10. MORMACBAY (MM)
11. MORMACCAPE (MM)
12. MORMACCOVE (MM)
13. MORMACGLEN (MM)
14. MORMACLAKE (MM)
15. MORMACPRIDE (MM)
16. MORMACSCAN (MM)
17. MORMACTRADE (MM)

C337
18. ADABELLE LYKES (LB)
19. AIMEE LYKES (LB)
20. ALLISON LYKES (LB)
21. CHARLOTTE LYKES (LB)
22. CHRISTOPHER LYKES (LB)
23. GULF BANKER (LB)
24. GULF FARMER (LB)
25. GULF MERCHANT (LB)
26. GULF SHIPPER (LB)
27. GULF TRADER (LB)
28. MARGARET LYKES (LB)
29. MAYO LYKES (LB)
30. SHELDON LYKES (LB)

C338
31. EXPORT ADVENTURER (AEL)
32. EXPORT AGENT (AEL)
33. EXPORT AIDE (AEL)
34. EXPORT AMBASSADOR (AEL)

C343
35. DEL ORO (Delta)
36. DEL RIO (Delta)
37. DEL SOL (Delta)

C346
38. EXPORT BANNER (AEL)
39. EXPORT BAY (AEL)
40. EXPORT BUILDER (AEL)
41. EXPORT BUYER (AEL)

C376
42. DELTA ARGENTINA (Delta)
43. DELTA BRAZIL (Delta)
44. DELTA MEXICO (Delta)
45. DELTA PARAGUAY (Delta)
46. DELTA URUGUAY (Delta)

C41A
47. ARTHUR MIDDLETON (WSS)
48. GEORGE WALTON (WSS)
49. IBERVILLE (PFEL)
50. JOHN B. WATERMAN (PFEL)
51. JOHN TYLER (PFEL)
52. THOMAS JEFFERSON (PFEL)

C41F
53. JOHN PENN (PFEL)
54. LYMAN HALL (PFEL)
55. THOMAS LYNCH (WSS)

C41H
56. EXPORT DEFENDER (AEL)
57. EXPORT DIPLOMAT (AEL)
58. JOSEPH P. HEWES (WSS

C41P
59. AUSTRAL PILGRIM (FL)
60. CARTER BRAXTON (WSS)
61. SAMUEL CHASE (WSS)
62. EXPORT DEMOCRACY (AEL)

C41T
63. CANADA BEAR (PFEL)
64. NATHANEL GREENE (WSSC)

C41U
65. HAWAII (SSC)
66. M M DANT (SSC)
67. OREGON (SSC)
68. SANTA ANA (P-G)
69. SANTA RITA (SSC)
70. WASHINGTON (SSC)

C457
71. AMERICAN CHALLENGER (USL)*
72. AMERICAN CHAMPION (USL)*
73. AMERICAN CHARGER (USL)*
74. AMERICAN CHIEFTAN (USL)*
75. AMERICAN CORSAIR (USL)*
76. AMERICAN COURIER (USL)*
77. PIONEER CONTENDER (USL)*
78. PIONEER CONTRACTOR (USL)*
79. PIONEER CRUSADER (USL)*
80. PIONEER MOON (USL)*
81. PIONEER COMMANDER (USL)*

C458
82. AFRICAN COMET (FLI)
83. AFRICAN DAWN (FLI)
84. AFRICAN MERCURY (FLI)
85. AFRICAN METEOR (FLI)
86. AFRICAN NEPTUNE (FLI)
87. AFRICAN SUN (FLI)

C464
88. AMERICAN RACER (USL)*
89 AMERICAN RELIANCE (USL)*
90. AMERICAN RANGER (USL)*
91. PRUDENTIAL OCEAN JET (P-G)
92. PRUDENTIAL SEAJET (P-G)

C466
93. DOLLY TURMAN (LB)
94. ELIZABETH LYKES (SL)
95. FREDERICK LYKES (LB)
96. GENEVIEVE LYKES (LB)
97. HOWELL LYKES (LB)
98. LETITA LYKES (LB)
99. LOUISE LYKES (LB)
100. MALLORY LYKES (LB)
101. MASON LYKES (LB)
102. RUTH LYKES (LB)
103. STELLA LYKES (LB)
104. VELMA LYKES (LB)

C4A
105. MOHAWK (MSI)

C4A1
106. ALEX STEPHENS (WSS)
107. ROBERT TOOMBS (WSS)
108. GREEN FOREST (CG)*
109. GREEN PORT (CG)*
110. GREEN WAVE (CG)

C4A1C
111. JAMES (JRT)

C4A3
112. GREEN LAKE (CG)*
113. GREEN SPRINGS (CG)*

C4A3C
114. TRANSCOLORADO (HWC)*
115. TRANSCOLUMBIA (HWC)*

*Under Charter Agreement to MSC.

TABLE A.9

U.S. FLAG BREAKBULK SHIPS CHARACTERISTICS SUMMARY

Shipping Category	Hull Desig	Qty Ships	Operator/ Owner	Max Boom Capacity	Number Hatches*	Hatch Sizes(LxW in ft.)	Year Built	Spd.	Remarks
U.S. Breakbulk Ships	C2	1	1-Victory	1-50	5	35,32.5,30,27x20	1945	15.5	Ship to be deactivated.
	C3	2	American Foreign SS	30	5	40,37.5,36,30x24	1945	16.5	
		1	WSSC	30	5	40,37.5,36,30x24	1945	16.5	
		3	AEL/GNOC/P-G	25	7		1945-46	16.5	
	C333	8	MM	2ships-60 6ships-75	5	40,37.5,35,24.8x22	1960-62	18.0	
	C337	13	LL	60	5	39.9,34.9,31.2, 29.9x24.9	1963-65	18.0	
	C338	4	AEL	50	6	40,30,20.3x31	1960-61	18.5	
	C343	3	Delta	60	17(7)	36,30,20,12x20	1961	18.5	
	C346	4	AEL	60	6	40,30,20.2x31	1961-62	18.5	2 others this class partial SS, 2 more SS
	C376	5	Delta	75	18(6)	35.9,40.4,29.9, 22.8,21.3x18.8	1968	18.6	
	C41A	3	WSS	60	7	40,30,25,20.3x30	1953	20.0	
		3	PFEL				1952		
	C41F	2	PFEL	60	7	40,30,25,20.3x30	1952-55	20.0	
		1	WSS						
	C41H	2	AEL	50	7	40,30,25,20.3x30	1952-54	18.5	
		1	WSS	60			1953	20.0	
	C41P	1	FLI	60	7	40,30,25,20.3x30	1954	20.0	
		2	WSS	60	7	40,30,25,20.3x30	1953	20.0	
		1	AEL						
	C41T	2	PFEL	60	6	42.5,35,32.5,30 29.8x28	1962	20.0	Booms married
	C41U	5	SSC	60	6	37.5,18x26	1962	20.0	
		1	P-G	60	6	37.5,18x26	1963	20.0	
	C457	11	USL	70	10(6)	42.5,35,27x33	1962-63	21.0	UCS-MSC
	C458	6	FLI	60	7	40,30,25,22.5x28	1962-63	20.0	
	C464	2	2-P-G	70	10(6)	42,32,30x30	1965-66	21.8	5 others this class are partial SS
	C466	12	LL	80	8(6)	42.3,39.8,34.8, 32.3,31.3x26.8	1966-67	20.0	
	C4A1-3	2	WSS	50	7(6)	30,17.3x17.5	1945	17.0	
		5	Calmar	35	4	75,65,19.7x30	1943-44	17.0	
		5	CG	2ships-70; 3-50	7(6)	42,30,20.3,18x18	1944-45	17.0	
		1	JRI	70	7(6)	42.5x18	1945	17.0	
		1	MSI	70	7(6)	42.5,30,18x18	1945	17.0	
		2	HWC	240	5	75x36	1945	17.0	Booms married; 120-T Divorced

* If number of hatches is the same as the number of holds, no further explanation is made; if number of hatches is greater than the number of holds, a parenthetical number will follow indicating the number of holds.

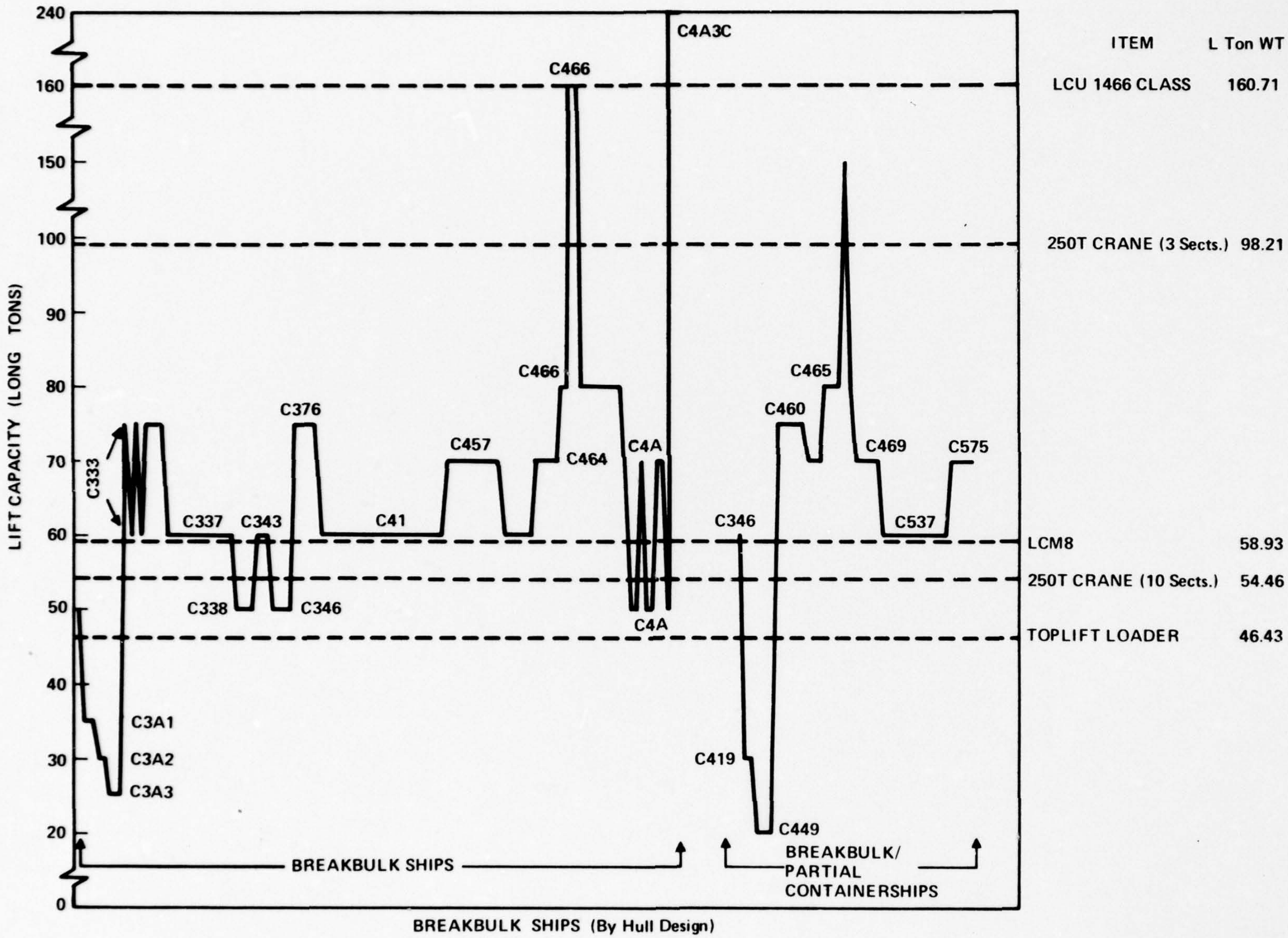

FIGURE A.1 DISTRIBUTION OF MAXIMUM BOOM CAPABILITIES BY HULL DESIGNATION AND CAPACITY TO LOAD SELECTED ITEMS OF LOTS HEAVY EQUIPMENT

TABLE A.10
SHIPS COMMITTED TO SRP (RFP-1000 SECOND CYCLE)

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	Lay Days and Ship Types Committed: 1-10	11-20	21-30	31-60
AEL	BB	15	9	-	1(C3)	3(C3), 1(C4)	2(C3), 2(C4)
	Cont	5	3	1(C573)		1(C573)	1(C573)
	RO/RO-Cont	o4	0	-	-	-	-

Comment: The C573 ship (AEL has 5) has a 1,076 20-foot container capacity, 20-knot speed, was constructed during the 1969-73 time frame, is non-self-sustaining, and services an East Coast - N. Europe Trade route. AEL has one C3 of limited capacity (25-ton boom maximum lift, 16.5-knot speed) that could be committed at any time. The other C3s are C346s - maximum boom capacity 60 tons, 18.5 knots, constructed 1961-63, two are considered partial containerships. C4s are either C41Hs or a C41P. The C41Hs were constructed 1952-54, have an 18.5-knot speed capability, and only 50-ton maximum boom. (Boom capacities expressed in long tons throughout.)

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
APL	BB	12	5	-	-	5(C575)	-
	Cont	18	7	-	-	3(C6QC) 2(C6)	2(C41Q)

Comment: The C575s are in reality partial containerships (387 20-foot capacity), have a 70-ton maximum boom capacity, were constructed from 1968-69, have a 20.8-knot speed, and are West Coast ships. The C6s could be C61Xs, C685s, or C669s. The C61Xs have a container capacity of 894 20-footers, were constructed 1961-64, and have 20-knot speed. The C685s have a 1,180 20-foot container capacity, were constructed from 1973-74, and have a 23-knot speed. The C669s have a capacity of 1,066 20-footers, were built during 1967-68, and also have a 23-knot speed. The C685s operate from the East Coast - Far East, the C669s and the C61Xs primarily from the West Coast - Far East. T containerships are non-self-sustaining.

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
C-G	LASH	3	2	-	-	2(C981)	1(C981)
	BB	1	1	-	-		1(C4)

Comment: The C981 was constructed in 1974-75, has a 22-knot speed, and a capacity for 89 barges (external size 61.5'x31'x13'). The C-G LASH ships have no dedicated container stowage space or handling equipment, although containers can be stowed in barge spaces in lieu of the barges (making the ships non-self-sustaining containerships--capacity approximately 1,200).

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
LB	BB	38	21	5(C337), 2(C466)	5(C337), 2(C466)	3(C337), 4(C466)	-
	Seabee	3	-	-	-	-	-

Comment: The C337 class was built 1963-65, has a maximum boom capacity of 60 tons, and an 18-knot speed. The 13 ships in this class operate from the Gulf and East Coast to Africa, the Mediterranean, India, Europe, and S. America. The C466 class was built from 1966-67, has a maximum boom capacity of 80 tons, and a 20-knot speed. The 12 ships in this class operated most the same route as the C337s.

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
PFEL							
	LASH	6	3	-	-	2(C881)	-

Comment: The C4 containerships (conversions) in PFEL service were built in 1943 and 1945, have a capacity of 544 20-foot containers, 17-knot speed, and a capacity for 25 automobiles. They operate from the West Coast to the Far East. The PFEL LASH ships have a capacity for 534 20-foot containers and 50 barges. The C881s are also equipped with a 35-ton gantry crane for a self-sustaining containership capability and it has a 450 ton gantry for barge loading/unloading operations. It is also possible to make barge tradeoffs to increase the container capacity.

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
P-G	BB	10	6	-	-	6(C4)	-
	Cont	4	4	-	-	4(C4)	-
	LASH	3	-	-	-	-	-

Comment: The C4s consist of a C41U, 2 C464s, 4 C449s, and 7 C465s... or any combination thereof. The C4 containerships could be either C449s or C465s, which are in reality only partial containerships. The C449 has two 40-ton gantry cranes and the C465s have an 80-ton maximum boom capacity. The C449 has a 21-knot capability while the C465 has a 20-knot speed. The C449s were built in 1962-63 while the C465s were built in 1966-67.

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
Matson	Cont	12	7	-	1(C3), 1(C4), 1(T2)	2(C4), 1(T2)	1(T2)
	RO/RO	2	-	-	-	-	-

Comment: The C3 was built in 1944, has a capacity for 488 24-foot containers, and a speed of 16.5-knots. The C4s were built in 1944-46 and have a capacity of 524-805 24-foot containers and a speed of 17 knots.

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	1-10	11-20	21-30	31-60
SL	Cont	51	24	-	-	6(C2C), 2(C2L), 1(C2Y) 2(T3J), 1 C4JC),	2(T3J), 2(C4JC) 8(SL-7)
	Cont-RO/RO	2	-	-	-	1(MIV), 1 FSX)	-

Comment: The following classes are self-sustaining:C2C--226 35-foot container capacity, built 1942-43, speed of 15.5 knots, uses two 26-ton capacity gantry cranes;T2 (the Summit)--226 35-foot container capacity, built in 1943, 14.5-knot speed, uses two gantry cranes;C2L--274 35-foot containers, built in 1944, 15 knot speed, uses two 22-ton gantry cranes;T3J--476 35-foot containers, built 1941-42, 15.5-knot speed, uses two 25-ton gantry cranes;C4JC--capacity of 602 35-foot containers, built 1942-44, 17-knot speed, two 22-ton gantry cranes;SL-7--non-self-sustaining, 1,096 35-foot container capacity, built 1972-73, 33-knot speed;the MIV and FSX are basically small-coastal ships with a capacity of 26-40 35-foot containers and a comparably small RO/RO capability.

TABLE A.10 (CONT.)

SHIPS COMMITTED TO SRP

Owner	Ship Type	Approx No. Ships Subj. to SRP	Total Number Ships Committed to SRP	Lay Days and Ship Types Committed 1-10	11-20	21-30	31-60
SS	BB	9	5	-	-	3(C4)	2(C4)
Comment:	Two types of C4 ships are involved, the C41LL and the C469 (partial containerships). The C41LLs were built in 1962, have a maximum boom capacity of 60 tons, 20-knot speed, and are primarily West Coast - Far East (one is East Coast - S. America).						
USL	Cont	16	8	-	-	4(C61W)	4(C61W)
Comment:	For general information--USL has 11 C457 breakbulkers under charter agreement to MSC. C457s have a 70-ton maximum boom capacity (78.4 short tons), 21-knot speed, and were built in 1962-63. The C61Ws have a capacity of 1,009 20-foot containers, were built in 1953-54, and have a 20-knot speed capability. They are East Coast - Europe Far Eash ships.						
WSS	BB	15	10	2(C4)	2(C4)	3(C4)	(C4)
Comment:	WSS has five classes of C4 hull designs, C41A, C41F, C41H, C41P, and EXC4. The C41 ships have basically the same cargo handling characteristics (60-ton maximum boom capacity), were built 1952-54, and vary mostly in speed capabilities (18.5-20 knots). The EXC4 ships have only a 50-ton maximum boom capacity and a 17-knot speed.						

NOTE: The following hull types are self-sustaining containerships:

APL - *C41Q*
C6QC

P-G - (see comment below P-G entry)

SL - C2C
C2L
C4JC
T3J

Total Ships Committed to SRP

Breakbulk	57
Self-sustaining containership	22
Non-self-sustaining containership	31
LASH	5
Total Commitment	**115**

TABLE A.11

OPERATIONAL SUITABILITY AND AVAILABILITY CRITERIA FOR SELECTION OF REPRESENTATIVE LOTS CONTAINERSHIP

MERSHIPS (BY HULL DESIGNATION)	NO. SHIPS EACH CLASS	1 AVAILABILITY: GROUP HAS EAST/GULF COAST TRADE ROUTE	2 AVAILABILITY: COMMITMENT UNDER SRP (IN LAY DAYS)	3 SUITABILITY: MAIN DECK OBSTRUCTIONS WHICH LIMIT CRANE OPS	4 SUITABILITY: PRIMARY CONTAINER CELLS ACCOMMODATE 20' MILVANS	5 SUITABILITY: CAPACITY > 600 CONTAINERS	6 SUITABILITY: CARGO AREA UNDIVIDED BY SUPERSTRUCTURE	7 SUITABILITY: SPEED (20 KTS.) CAPABILITIES	8 SUITABILITY: 40' CONTAINER SECONDARY CAPACITY	TOTALS	GROUP RANKING BY AVAILABILITY	REMARKS
NSS SHIPS												P-PREFERRED, A-ALTERNATIVE
C2X	4	4	2	4	0	1	2	0	0	13		
XT2E	3	0	3	4	0	4	4	0	4	19		
T2M	3	4	0	4	0	2	4	0	0	14		
T2/C4	3	4	0	1	0	2	4	0	0	11		
EXC3	1	0	3	4	0	2	2	0	0	11		
PFEL-EXC4	2	0	2	4	4	3	3	1	4	21		
Mat-EXC4	2	0	2	4	0	3	4	2	4	19		
Mat-EXC4B	2	0	2	4	0	4	4	2	4	20		
PRMA/ST-EXC4	4	4	2	4	0	3	4	2	4	27	1A	Best Alternative (40' Containers)
C4J	4	4	0	4	0	4	4	2	4	23	2A	
C4J1	2	4	0	3	0	4	4	2	4	21	4A	
C4X	9	4	0	4	0	2	4	2	4	20		
C573	5	4	4	4	4	4	4	4	4	32	1P	Most Representative
C61W	8	4	2	4	4	4	2	4	4	28	2P	
C61X	4	0	0	4	4	4	2	4	4	22		
C669	5	1	0	4	4	4	4	4	4	25	3P	
C685	8	4	0	4	4	4	4	4	4	28	2P	Preferred Test Ship
C768	8	1	0	4	4	4	3	4	4	24	4P	
C788	2	4	0	3	0	4	4	4	4	23	2A	
SL-18	2	4	0	3	0	4	4	4	4	23	1A	Best NSS Alternative
SL-7	8	4	1	4	0	4	2	4	4	23	2A	
Mat-H.ENPR	2	0	0	3	0	4	4	4	4	19		
SS SHIPS												
C2C	6	4	2	4	0	1	2	0	0	13		
C2L	2	0	2	4	0	1	2	0	0	9		
EXT2	1	4	0	4	0	1	4	0	0	13		
T3J	4	4	2	4	0	3	4	0	0	17		
C4JC	3	4	2	3	0	4	4	1	0	18		Preferred SS

WEIGHTING CODES

Code	Cols. 1, 3-6	Col. 2 (SRP Commitment in Lay Days)	Col. 7 (Speed in knots)	Col. 8 40'Container Capacity
4	90-100% capacity/capability	1-10	> 20	> 50 containers
3	70-89% capacity/capability	11-20	19	—
2	50-69% capacity/capability	21-30	18	—
1	20-49% capacity/capability	31-60	17	—
0	no significant capability	Uncommitted	< 16	No capacity at all

TABLE A.12

OPERATIONAL SUITABILITY AND AVAILABILITY CRITERIA FOR SELECTION OF APPROPRIATE LOTS BREAKBULK SHIPS

MERSHIP CLASSES (CLASSES WHICH INCLUDE MSC CHARTER SHIPS NOTED BY ASTERISK)	NO. SHIPS EACH CLASS	1 AVAILABILITY: HAS EAST/GULF COAST TRADE ROUTE	2 AVAILABILITY: COMMITMENT UNDER SRP (IN LAY DAYS)	3 SUITABILITY: CAPABILITY OF HEAVY LIFT BOOM TO HANDLE LOTS EQUIPMENT (SEE NOTE)	4 SUITABILITY: HATCH SIZE CAPACITY TO LOAD LOTS EQUIPMENT	5 SUITABILITY: SPEED (20 KTS.) CAPABILITIES	6 SUITABILITY: SECONDARY BOOM LIFT CAPABILITIES	7 SUITABILITY: 20-FOOT CONTAINER CAPACITY	TOTAL	RANKING	REMARKS
BB SHIPS											
C2A5	1	4	0	0	1	0	2	0	7	13	
C3A1	3	4	0	NC	4	1	1	0	NC	--	
C3A2	2	4	0	NC	2	1	2	0	NC	--	
C3A3	3	4	3	NC	2	1	1	0	NC	--	
C333	8	4	0	4	2	2	1	0	13	11	
C337	13	4	4	4	2	2	1	0	17	7	
C338	4	4	4	0	2	2	1	0	13	11	
C343	3	4	0	4	1	2	1	0	12	12	
C346	4	4	4	0	2	2	1	0	13	11	
C376	5	4	0	4	1	2	3	0	14	10	
C4A	1	4	0	4	3	1	1	0	13	11	
C4A1*	5	4	4	0	3	2	2	0	15	9	2 Under Charter to MSC
C4A1C	1	4	0	4	3	2	1	0	14	10	
C4A3*	2	4	4	4	3	2	2	0	19	5	2 Under Charter to MSC
C4A3C*	2	4	4	8	4	1	4	0	25	1	2 Under Charter to MSC
C41A	6	4	4	4	2	4	3	0	21	3	
C41F	[illegible]	4	4	4	2	4	1	0	19	5	
C41H	3	4	4	4	2	3	1	0	18	6	
C41P	4	4	4	4	2	4	1	0	19	5	
C41T	2	4	4	4	3	4	2	0	21	3	
C41U	6	4	2	4	1	4	2	0	17	7	
C457*	11	4	4	4	3	4	1	0	20	4	11 Under Charter to MSC
C458	6	4	0	4	2	4	1	0	15	9	
C464*	5	4	2	4	3	4	1	0	18	6	3 Under Charter to MSC
C466	10	4	4	4	3	4	2	0	21	3	
C466	2	4	4	6	3	4	2	0	23	2	Have 160-Long Ton Boom Marriage Capability
PART CONTAINER											
C346	2	4	4	4	2	2	1	4	21	3	
C41Q	2	0	0	NC	1	4	2	4	NC	--	
C449	4	0	2	NC	3	4	2	3	NC	--	
C460	6	4	0	NC	3	4	1	3	NC	--	
C464*	3	4	0	4	3	4	1	3	19	5	1 Under Charter to MSC
C465	5	0	2	4	3	4	2	3	18	6	
C465	1	0	2	6	3	4	2	3	20	4	Has 150-Long Ton Boom Marriage Capability
C469	5	0	2	4	1	4	2	3	16	8	
C537	13	4	0	4	2	1	1	3	15	9	
C575	5	0	2	4	3	4	2	4	19	5	

WEIGHTING CODES

Code	Col.1	Col.2 (SRP Lay Days)	Col. 3 (Lift Capacity)	STon requirement	Col. 4 (Hatch Size)	Col. 5 (Speed)	Col. 6	Col. 7 (No. Slots)
4	East/Gulf Coast	1-10	LCU	>180	Length >49'	>20	>120 LTons	>400
3	Laid up	11-20	250-ton crane(in 3 sections)	>110	>42'	19	> 60 LTons	>200
2	—	21-30	LCM8	> 66	>38'	18	> 20 LTons	>100
1	—	31-60	250-ton crane(in 10 sections)	> 61	>30'	17	> 10 LTons	> 50
0	West Coast/ foreign service	Uncommitted	Toplift loader	> 52	< 30'	< 16	<10 LTons	No designated slots

NOTE: NC = No significant capability. Vessels having this entry were eliminated from further consideration. Because of the greater relative importance to LOTS of this criterion an additional weighting factor of x2 was used for column 4.

APPENDIX B

COMMENTS ON STABILITY OF BARGES AND SHIPS

BARGE STABILITY

Calculations of the stability of rectangular barges and of ships are helpful in discussing the uses of certain of the LOTS-related equipment mentioned in this report. One section of this appendix shows the assumptions made and principles followed in performing the calculations on barges. Another section shows a calculation of the stability of a DeLong "B" barge with a 250-ton crane operating from its deck. A third section discusses ship stability, with particular reference to the use of mobile cranes on deck.

Equilibrium Conditions

The fundamental process in considering stability is to calculate two moments, expressed in foot tons. One is the overturning moment caused by an off-center load. The second is the restoring moment that occurs as a consequence of the barge tipping from the load. The two moments are equal and opposite when there is an equilibrium situation. Figures B.1 and B.2 show cross-sections through a barge for two equilibrium situations, one with the barge on an even keel and the second with the barge listing as consequence of the load shift.

To calculate the overturning moment, the eccentric load, in long tons, is simply multiplied by the distance it has been moved, in feet. In the initial explanation, no new load is applied; the load on the barge is simply shifted sideways.

The calculation of the restoring moment makes use of the concept of the metacenter. This is a theoretical point which, for present purposes, is at the intersection of the barge centerline and a vertical line through the changed center of buoyancy, as shown in Figure B.3, (in which, like the preceding figure, the angle of inclination is exaggerated). The calculations considered here involve only small angles of inclination (up to about 6 degrees) and for this range

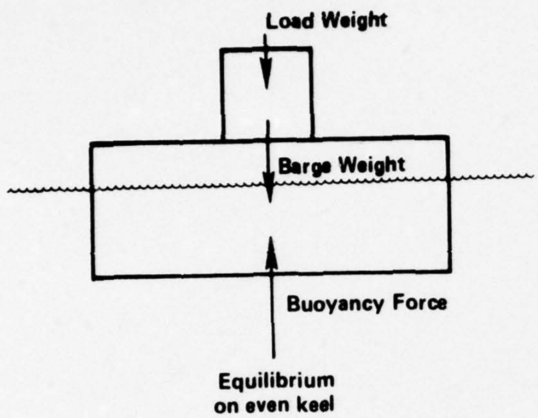

FIGURE B.1. BARGE WITH NO LIST. Equilibrium between upward force of buoyancy and total of barge weight and load weight.

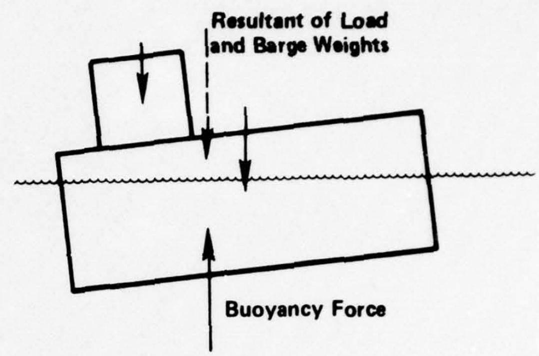

FIGURE B.2. LOAD SHIFT HAS CAUSED LIST. Equilibrium between upward force of buoyancy, now displaced toward left, and the sum, shown dotted, of the barge weight and load weight.

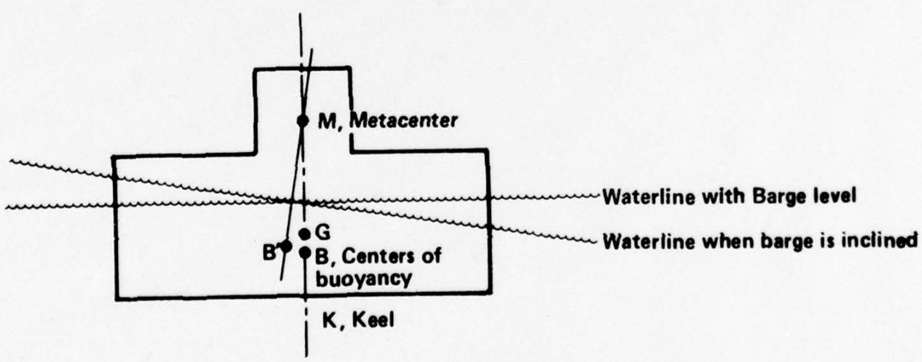

FIGURE B.3. CONCEPT OF METACENTER. Metacentric Height is MG, distance from metacenter to center of gravity of barge plus its load.

the metacenter does not change position appreciably. The metacentric height is the vertical distance from the initial center of gravity. As can be seen in Figure B.3:

$$GM = KB + BM - KG.$$

The vertical position above the keel of the center of buoyancy, KB, is readily found for rectangular barges (it is half the draft). The height of the center of gravity, KG, can be calculated (or, for uncomplicated barge structures, estimated). For rectangular barges BM is calculated quite simply:

$$BM = \frac{\text{Beam}^2\ {}^{1/}}{12 \times \text{Draft}} .$$

The list angle for a barge with an asymmetric load is found from:

$$\text{Sine of Angle} = \frac{\text{Tons of Eccentric Load} \times \text{Eccentricity}\ {}^{2/}}{\text{GM} \times \text{Displacement of Loaded Barge, in Tons}} .$$

Example Calculation (See Figure B.4)

Find the resultant list angle if a load weighing 50 long tons is moved from the centerline of a causeway ferry barge to a point 2 ft to one side of the centerline. The ferry has a beam of 21 ft and a draft, with the load, of 2 ft. The estimated KG of the load and barge together is 6 ft. The loaded displacement is 110 long tons. Then:

$$KB = \tfrac{1}{2} \times 2 \text{ ft} = 1.0 \text{ ft}$$

$$BM = \frac{21^2}{12 \times 2} = 18.4 \text{ ft}$$

$$GM = KB + BM - KG = 1.0 + 18.4 - 6 = 13.4 \text{ ft}$$

$$\text{Angle of list} = \text{angle whose sine is } (2 \text{ ft} \times 50 \text{ tons}) \div (13.4 \text{ ft} \times 110 \text{ tons})$$

$$= 3.9^{\circ}$$

Some Limits to Listing

As will be seen from the expression for the list angle given above, any increase in the applied moment results in a proportional increase in the sine of the list angle. But the expression does not apply when the list becomes

---

1/ Derivation: For any floating body BM equals the moment of inertia of the waterplane about the centerline, divided by the immersed volume. For a rectangular barge, the moment of inertia = Length x $(\text{Beam})^3$ ÷ 12, and the volume = Length x beam x draft. Note that when the dividing is done, the result is independent of length. (The length, though, must always be greater than the beam.)

2/ Note that the moment arm of the restoring force is the distance from the center of gravity (G on Figure B.3) to the line joining the inclined center of buoyance and the metacenter. Its numerical value is GM x the sine of the inclination angle.

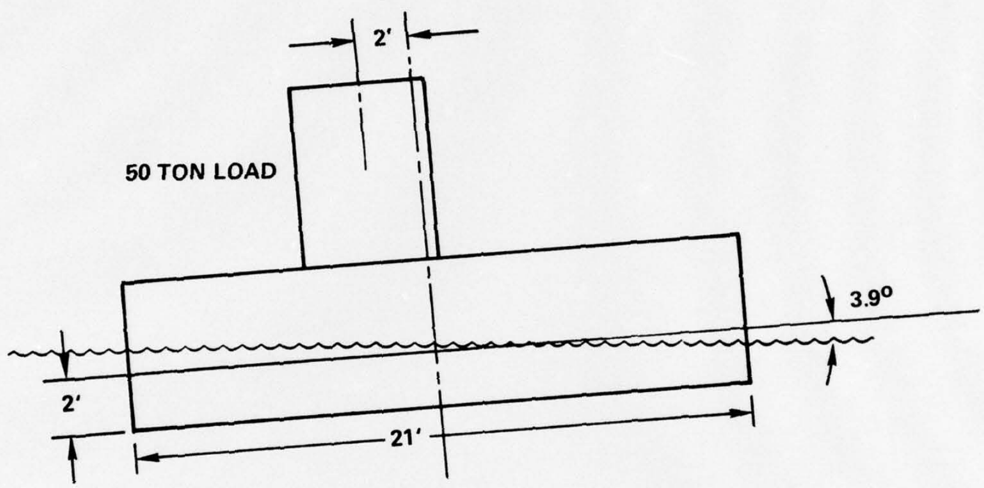

FIGURE B.4. CAUSEWAY FERRY WITH 50-TON LOAD 2' OFF CENTER

large enough to put the deck edge of the barge under water, nor if part of the barge bottom emerges from the water. When either of these happens, an increase in applied moment is no longer necessarily met with an increase in the restoring moment. Still further increases in the applied moment may result in decreased restoring moment and capsize.

Figure B.4 shows, to scale, the draft and the list angle of the example. The load shown does not appear to be at all close to capsize.

Suppose that the example above is changed. The load now is to be heavier, a 6250TC crane in the tactical movement configuration, weighing 98 long tons. The total weight of causeway ferry and crane together is then 158 long tons, and the corresponding draft for the combination is now 2.9 ft. The estimated KG of the load and barge increases to 7.2 ft. Then:

$$GM = KB + BM - KG$$

$$= 2.9 \div 2 + \frac{21^2}{12 \times 2.9} - 7.2 = 6.92 \text{ ft.}$$

Note that this metacentric height is quite drastically reduced from that of the previous example. As before, consider a 2 ft shift of the weight. Then the list angle equals,

$$\sin^{-1}\left(\frac{2 \text{ ft} \times 98 \text{ tons}}{6.92 \text{ ft} \times 158}\right) \text{ or } 10.3^{\circ}.$$

The freeboard of the causeway ferry with such a load on an even keel would be 2.1 ft. The angle at which the deck edge would submerge from a shifting load has a sine of 2.1/21 ft ÷ 2 or .20, and the angle is 11.5°.

Thus, a shift of 2 ft in the load would result in immediate danger of a capsize. It is concluded that the 6250TC crane can be carried ashore onboard a 21-ft beam causeway ferry only if there is assurance that the load center of gravity can be securely positioned within about 1 ft of the barge centerline.

Stability of DeLong "B" Barge (See Figure B.5)

Problem: Find the change in list angle of a DeLong "B" barge if a 6250TC crane on its deck unloads or picks up a 20-long ton container at a crane radius of 120 ft. (This combination of load and reach results in the largest moment for which the crane is designed.) Assume the barge deck has been strengthened by placing plates on the deck to spread the load. The plates are 3/4 inches thick and weigh 13 long tons. The pertinent weights and c.g. locations are:

	Weight, L Tons	Vertical center of gravity, above keel
Barge	650	5 ft
Plates	13	10 ft
Crane w/150 ft Boom	163	15 ft
Container	20	121 ft
Total	846	

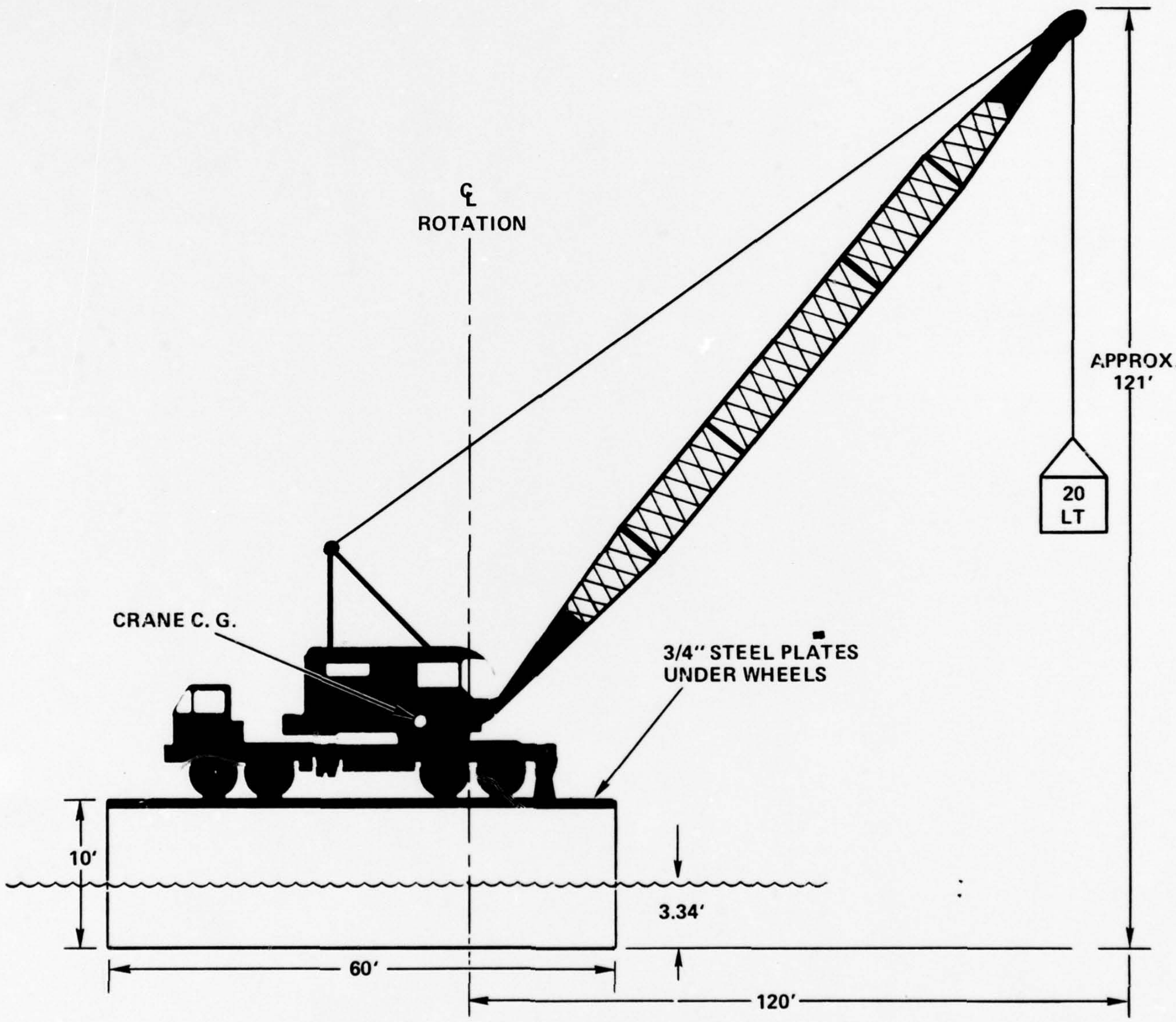

FIGURE B.5. P&H 6250TC CRANE ON "B" DELONG BARGE.
Dimensions pertinent to stability calculations for barge.

Note that the weight of the container is assumed to act at the height of the boom tip, since it is a suspended load (a 140-ft boom length is assumed). The barge dimensions are 150 ft long, 10 ft deep, and 60 ft beam.

Step # 1, calculate average draft:

$$\text{draft} = \frac{846 \text{ L Tons x } 35 \text{ cu ft/ton}}{60 \text{ ft beam x } 150 \text{ ft length}} = 3.3 \text{ ft.}$$

Step #2, calculate vertical c.g. (i.e., "KG"):

$$(650 \times 5 \text{ ft} + 13 \text{ ft} \times 10 + 163 \times 15 + 20 \times 121)/846 = 9.72 \text{ ft} = KG$$

Step #3, calculate GM = KB + BM = KG:

$$CM = 3.3\ /2 + \frac{60^2}{12 \times 3.3} - 9.72 = 82.8 \text{ ft} = \text{metacentric height.}$$

Step #4, find change in angle:

$$= \sin^{-1} (120 \text{ ft} \times 20 \text{ tons})/(82.8 \text{ ft} \times 846 \text{ tons}) = 1.96^{\circ} \text{ change in angle.}$$

Conclusion: The amount the "B" DeLong heels, under the largest moment for which the 6250TC crane is rated, is well within the feasible operating limits of the barge.

SHIP STABILITY

The concept of a righting moment dependent on metacentric height, already explained for barges, also applies to ships. Calculation of the value of metacentric height is not discussed here, since for any particular ship of concern it is computed for each loading. In general, typical values are from one to six or eight feet— generally less than those for barges. These smaller values, however, are multiplied by considerably larger displacements to find the righting moments, so that heel angles are generally of the same order as for barges.

Heel or List Angle for Crane-on-Deck Concept

Calculations were made of the greatest increase in heel angle that would be encountered on a typical non-self-sustaining containership (the C6-S-85 hull) as a 58 long ton load (e.g., an LCM8) changes from being supported by the water to being supported by the 140-ton crane. The heel is in the neighborhood of four degrees. The calculation was for the ship in a full-load condition at the end of a voyage. This is the time when the ship would unload the heavy equipment. It also is the time, according to calculations made at the Maritime Administration[3] when the ship is least "stiff" as measured by calculated metacentric heights.[4]

[3] Maritime Administration, U. S. Department of Commerce, Office of Ship Construction, Division of Ship Design, Crane on Deck Study for NSRDC, MARAD PD-202, June 1975, (The publication shows calculations of metacentric heights but not heel angles.)

[4] To calculate the heel angle, the metacentric height should be adjusted to take into account the fact that the load is suspended. The vertical position of the load is taken as the height of the boom tip of the crane. (The treatment of a suspended load is analagous to the treatment of a free-surface liquid. Both load position and free surface move in response to heel angle.)

The question of what crane de-rating is necessary because of heel or list angles and because of wave action is the subject of a Navy research project. Part of the de-rating is associated with the capability of the crane to swing around a vertical pivot when the gear ring which actuates the swing is not level. Another part has to do with the increased reach of the crane that occurs when the ship heels under the crane's load. The following paragraph concerns the latter problem and presents an argument that no de-rating needs to be used for the temporary condition of heeling in response to an overside load in calm water so long as the boom is well topped up, and well under its critical angle, during the swing motion.

Consider as an example the C6-S-85 ship, floating level. Assume that a 9125TC crane on the ship deck picks up a 58-long-ton load from the deck beside it, using a 60-foot heavy-lift boom tip with the boom nearly vertical and well within the limits shown on the rating plate and Figure 4 (which was derived from the rating plates). With the boom angle unchanged, rotation begins, and the load is swung over the side. The ship begins to heel. The heel makes the boom a little more nearly horizontal, although the boom-lift cable has not been let out any further. The loading presumably is closer to the limit shown on the plate than it was before. The heel angle, though, has provided the advantage of moving the suspended load horizontally a little further clear of the ship side. The boom-lift cables are then let out until the boom is in the most nearly horizontal position permitted for the weight of the load. The load itself is somewhat further clear of the ship than it would be if no heel had occurred. In this case, it is assumed, the boom angle, measured relative to the vertical, rather than the boom reach, becomes the measure of the lifting limit. (When the crane operates on the level, either angle or reach could be used as the load-limit measure.)

It is postulated that, with the procedure outlined, the standard rating-plate loads can be used for crane-on-deck operations in smooth water. In any event, careful calculations of the predicted heel angle, and readjustment of the metacentric height by shifting cargo or ballasting may be necessary when near-maximum loads are being tested. As a precautionary measure, pending physical verification of the procedure described above, the LOTS containership pretest (140T Crane-on-Deck) proposes use of simultaneous, <u>opposing</u> lift to minimize any potential heeling effect.

APPENDIX C

MOBILE CRANES ON THE DECK OF A NSS CONTAINERSHIP

This appendix discusses certain of the operating problems that should be expected in using a mobile crane on the deck of a containership. Tentative solutions are outlined for these problem areas. It is expected that detailed planning will produce more detailed alternative solutions. In the discussion the C685 NSS containership is used as an example. For using other ships, calculations of the same type, plus detailed considerations, must be undertaken before a test operation.

CHANGES IN ANGLE OF THE SHIP DECK

At near-limit loading of the crane during the equipment deployment phase of a LOTS operation, changes in the angle of the ship deck need to be taken into account. The change in angle can have three sources. One is the list angle caused by placing a load on the crane. The effect on a lifting operation of such a list may be a change in the crane's rated capacity, and is discussed in Appendix B. A second source of change in ship list angle is the unloading of the ship's cargo. The crane operator can compensate for such a change by leveling his crane using hydraulic outriggers. Alternatively the ship can shift ballast. A third possible cause for change in angle is less easy to allow for— the rolling or pitching caused by waves. This can affect not only the crane tipping moments but in extremes could result in out-of-line stresses which the crane may not be designed to accept. Such moments and stresses are not well understood. Studies of them have been undertaken, and more are proposed. The only recourses, when there is a need to move heavy lifts when dynamic roll angles are possible, are to allow substantial safety margins in the operations, or to conduct them only in-harbor or when the waves are small enough not to result in appreciable ship motion. In the material which follows, only static forces are considered.

FORCES ON DECK OF SHIP GENERATED BY A CRANE LIFTING A HEAVY LOAD

Figure C.1 shows a simplified version of what happens when a crane picks up so extreme a load that the crane is almost ready to tip forward. The overturning moment caused by the load is shown being balanced by the weight of the crane acting downward at the crane center of gravity. The ship deck resists with an upward force acting through the outriggers. The magnitude of this force is equal to the weight of the crane plus load. The weight on the other pair of outriggers is zero. Such a situation is not permissable in practice— the published limits shown on the load plate for the crane are based on, at most, 85 percent of the load when such tipping is about to begin. This limit applies strictly to certain boom angles intermediate between vertical and horizontal. For example, for a 60-foot boom these angles are between approximately 75^o and 31^o, measured from deck level. For near-vertical or near-horizontal boom positions, the load limits are less and are associated not with crane tipping, but rather with strength-of-material limits. The result, for present purposes, is that the maximum load on the outriggers nearest the load is, at most, 85 percent of the combined weight of the crane and the load.

Figure C.2 shows schematic top views of the way this load is distributed for the 140-ton capacity P&H 9125 Crane. When the crane boom is over the carrier centerline (the top part of the figure), the load transmitted to the ship deck is divided equally by the two outriggers. When the crane boom swings approximately 50^o until its centerline is over the outrigger (bottom part of figure), very nearly the whole force is concentrated on one outrigger instead of being shared between two. *The deck strength, then, must* be able to resist as much as 85 percent of the whole weight of the crane and its load, concentrated on the single outrigger. For the P&H 9125 TC Crane lifting an LCM8, the heaviest load considered in this study, this maximum amounts to 251,000 pounds on one rear outrigger.

STRENGTH OF EDGE OF DECK FOR HEAVY LIFTS OVER THE SHIP SIDE

Modern self-sustaining containerships are so designed that they are able to take concentrated loads of this magnitude when they are applied near the deck edge (which is where the strength is needed for the near-limit lifts under discussion). Figure C.3 shows a section through the box beam at the deck edge of a C6-S-85a containership, considered typical of U. S. non-self-sustaining containerships.

Rough calculations of the strength were made, verifying that the structure could carry considerably more than the load from the crane outrigger. The calculations assumed that the load was concentrated at a fore-and-aft point halfway between the bulkheads forming the cargo holds, and that the structure spanning this 50-foot distance acted as a simple beam in transmitting the load to the bulkheads. To make the calculations, it was assumed that the box beam structure was separated from the rest by hypothetical cuts made at the fore and aft ends of the 50-foot span and along the side of the ship at the outside lower corner of the box. The box thus separated has two horizontal elements. These are the 9'9" wide section of plating forming the weather deck and the parallel lower section that provides the bottom of the box. The two vertical elements are a 9' section of the ship's side and the parallel inboard plating located under the hatch coaming. For simplicity the tees and channels shown in Figure C.3 were left out, as was the section of coaming. Even with the parts not considered and with the arbitrary separation (the tie-ins of structure that are actually acting would in fact greatly

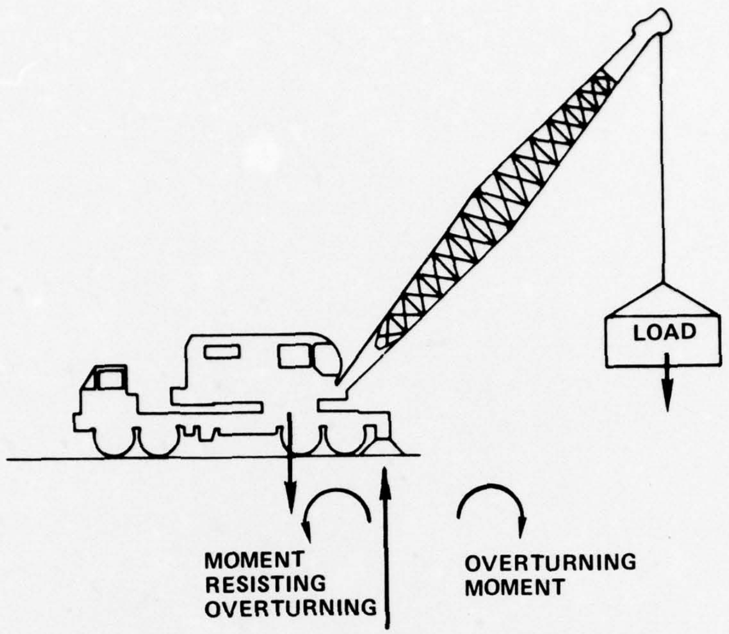

FIGURE C.1. SCHEMATIC OF OVERTURNING MOMENT AND THE MOMENT RESISTING OVERTURNING -- CRANE BOOM PARALLEL TO CARRIER CENTERLINE

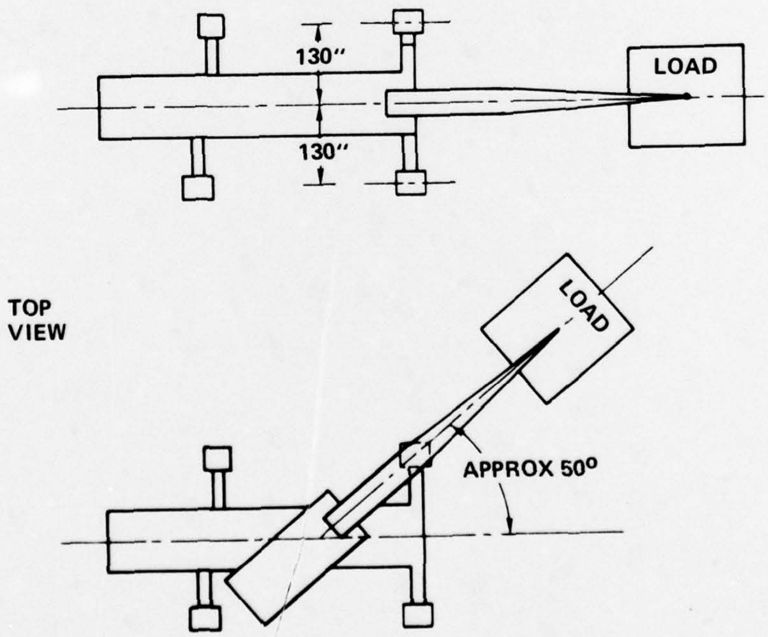

FIGURE C.2. SCHEMATIC TOP VIEW OF CRANE WITH HEAVY LOAD.

(Showing: a) major load shared between two outriggers when crane boom is swung aft; b) major load concentrated on single outrigger when upper is swung so boom is over outriggers.)

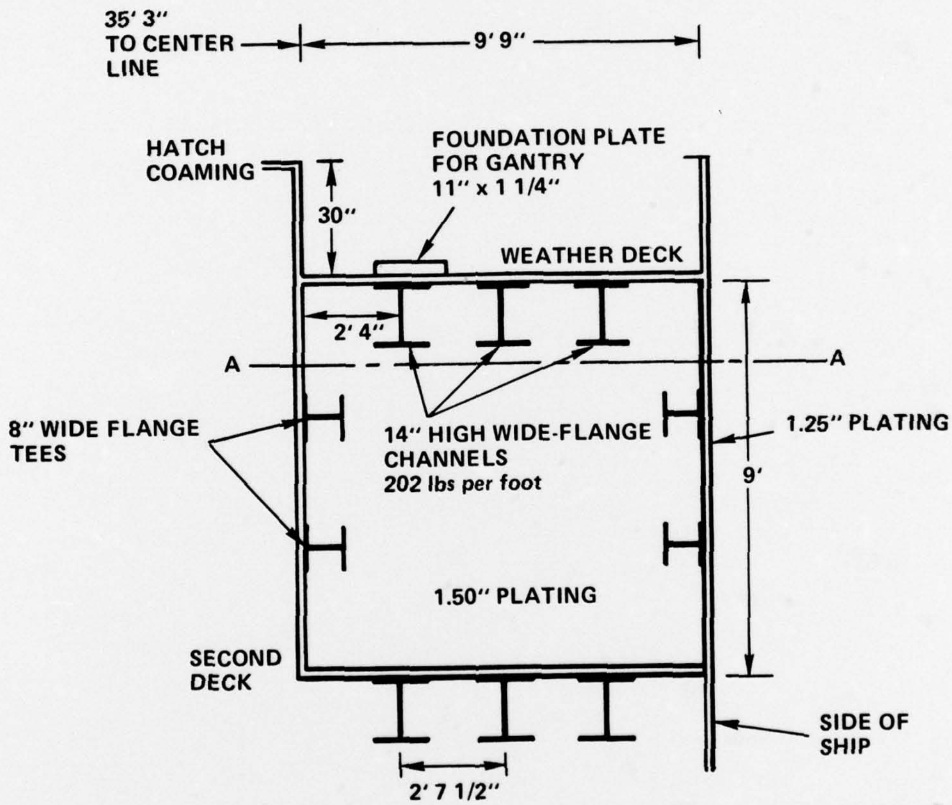

FIGURE C.3. SECTION AT DECK EDGE OF C685 NSS CONTAINERSHIP
(Shows box section acting as ships longitudinal strength member.
Considered typical of current U. S. containership designs.)

increase the strength) the calculated strength of the box in bending in an order of magnitude greater than needed to carry the load of the outrigger pad when the crane is lifting the LCM8.[1/]

STRENGTH OF HATCH COVERS AND HATCH BRIDGING REQUIRED

As has already been seen, for modern NSS containerships the space between the hatch coamings and the outer edge of the deck is relatively narrow. For example, in Figure C.3, the distance is 9'9" for the C6-S-85a design. Since the 140-ton crane is longer and wider than this, even without outriggers, it must operate at least partly over hatch openings, using hatch covers or other bridging. (Means for making the operating surface nearly level are discussed in a later section.) For lifting heavy equipment, the crane's rear outriggers would be supported by the strength members of the ship near the deck edge, as already discussed. The outriggers inboard, at the crane front, would have to be supported by beams on top of the hatch covers, discussed below. For lifting containers, the crane might well be amidships, and positioned over the hatches entirely, since it could then more conveniently reach into hatches at the two sides of the ship, and since the need for limiting the crane reach may be less pressing than it is for the heavier lifts of LOTS equipment. For either the heavy lift operations or container operations, then, the support of the crane over the hatch openings has to be considered. The problem of the hatch cover strength needed during the moving of the crane over the hatches involves less weight. It is discussed first.

The *American Bureau of Shipping* rules include a requirement that steel hatch covers be capable of withstanding a uniform loading of 358 lbs per square foot. A 20' x 35' hatch cover, with its 700 sq ft, then, could be expected to carry a uniformly spread total load of 250,000 lbs, or 112 long tons. The P&H 9125 TC Crane with a 120-ft boom and the 62,000-lb counterweight, a configuration suitable for handling containers, weighs approximately 89 long tons. Thus, if the load were in fact evenly distributed, the hatch cover would be more than sufficiently strong to handle the weight of the crane alone. But the crane exerts concentrated loads, either in moving from location to location aboard ship across the hatches or in operating over hatches. Thus, the loads and required strengths must be investigated.

Two aspects of the hatch cover strength are discussed here: the resistance to a bending load, which needs to be greatest when the load is at the center of the hatch span; and the resistance to shearing of a hatch beam web, which needs to be greatest when the load is just inside the coaming.

<u>Loads During Moving of Crane</u>

During movement, the crane weight is transmitted downward through 12 tires and is thus not so concentrated as it can be through the outrigger plates during lifting operations. For present calculations the weight is considered to be concentrated at four points, two on each side, an assumption on the safe side. At the

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[1/] The concentrated load of 251 Kips with a 50-ft span results in a bending moment Of 37.6×10^6 in.-lbs. This, in turn, requires a section modulus of 2091 in^3 to support the load. The calculated section modulus is over ten times this value.

front the concentration is assumed to be halfway between the two front axles, and at the rear halfway between the two rear axles (see four filled-in dots in Figure C.4). With the crane counterweight swivelled toward the rear, a large proportion of the load is on the eight rear tires. By analogy with the weight proportions for road travel found in the P&H literature, 84 percent of the weight of the crane is assumed to be on the rear. This is 75 long tons. With 5 tons added for moving hatch bridges (discussed later), 80 tons is the controlling weight considered here.

The wheelbase of the crane is 19'2", so the worst bending moment on the hatch cover occurs with the crane centerline parallel to the ship centerline and the 80 long tons at the athwartship centerline of the hatch cover. The front axles are off the hatch and do not contribute to the bending. The beams in the hatch cover that resist this bending are on approximately 8'9" centers, and the side-to-side center distance for the rear tires is 8'4", so that two hatch cover beams can be considered to share the rear axles load and carry 40 long tons each. The resulting bending moment on each hatch beam is 5.37 x 10^6in.-lbs. The corresponding section modulus required to resist this bending is 300 in^3. The actual section modulus for the C6-S-85a hatch beams is less than half of this value, so bridging beams must be used for moving the crane across the hatches.

Hatch Bridging

Bridging for permitting mobile cranes to move along the decks of merchant ships and lift containers is being studied in detail in Navy-sponsored projects. The results of these studies are not yet available. The discussion that follows outlines certain of the problem areas and shows possible solutions that may be treated in the Navy studies. In addition, it addresses heavy lift problems and maneuvering to place the crane athwartships for heavy lifts, aspects that are thought to be outside the present scope of Navy tasking.

Timber bridging to support the crane was investigated. The deflection of timber beams is very large compared to steel beams of the same rated strength. Thus, the calculated deflection for two 12 x 12 timbers bolted together (selected as having more than the required section modulus of 300 in^3) is 5½" in a 20-ft span under a 40-ton load. This is judged not acceptable. However, if the bridging was assembled instead from three 18-in. square sections (see Figure C.5), the deflection would be reduced to just over ½ inch. Each such section 22 ft long would weigh just under 5000 lbs. In use, the sections would have to be supported with the ends elevated above the hatch cover tops to allow the beam to deflect without touching the hatch top. Otherwise, the load would be shared by the hatch cover to an extent difficult to ascertain.

Another possible form of bridging would be use of specially fabricated built-up steel plates such as the one also sketched in Figure C.5. The plate shown was made especially wide in order to cut down the number of plates to be moved during crane maneuvering, which is discussed in a later paragraph.

Shear Stresses in Hatch-Cover-Beam Webs

Figure C.6 sketches a typical cover beam of the C685 ships. There are three such beams in each hatch cover, not counting the hatch cover ends. The cover framework shown is for double hatches. One end is supported by the hatch coaming, the other by a special ship structure that can be removed to accommodate 40-ft containers. Thus, the hatch beam terminates at one end (the left end in the figure) in a configuration that lies on top of the hatch coaming. At the other end, the hatch

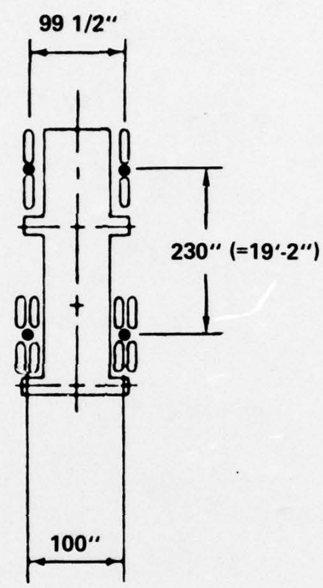

FIGURE C.4. TIRE CONFIGURATION AND ASSUMED LOCATION OF LOAD CONCENTRATION AREAS (●'s) USED IN PRELIMINARY HATCH-BRIDGE CALCULATIONS, P&H 9125TC CRANE

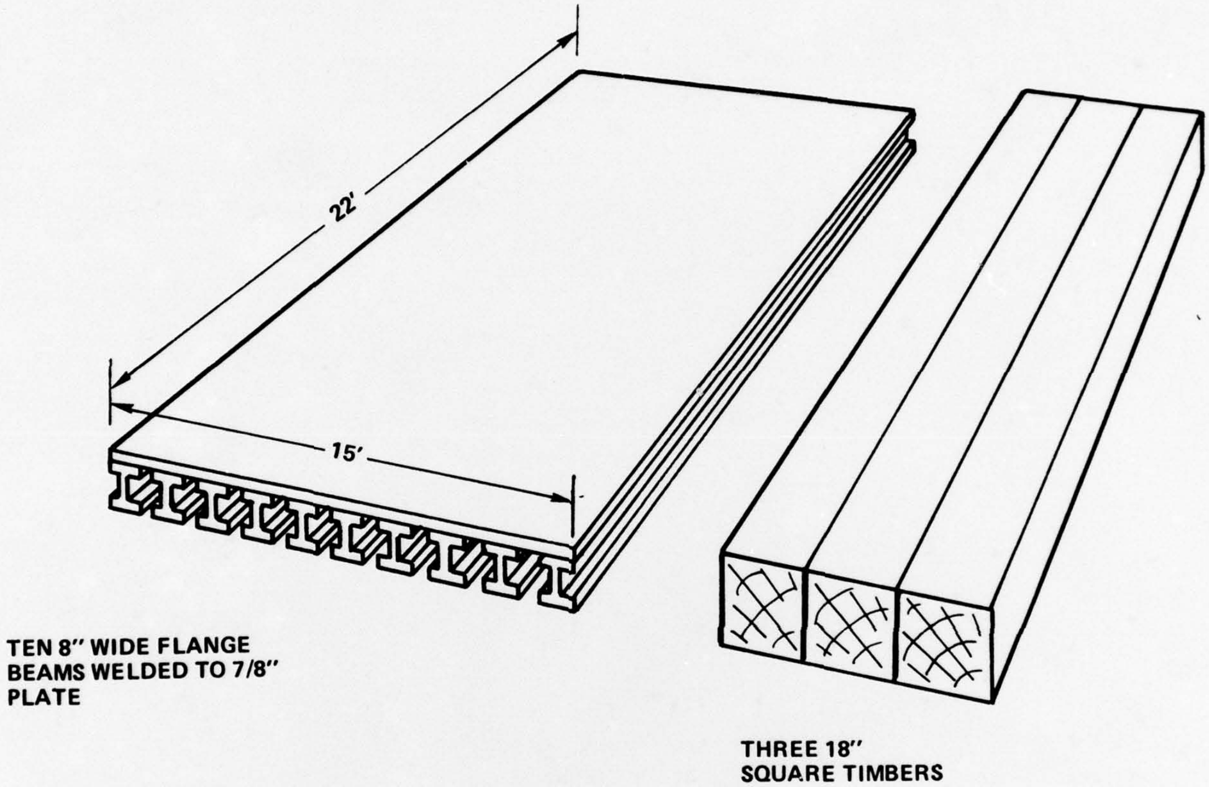

FIGURE C.5. ALTERNATIVE HATCH BRIDGING BEAMS FOR CRANE TRAVEL

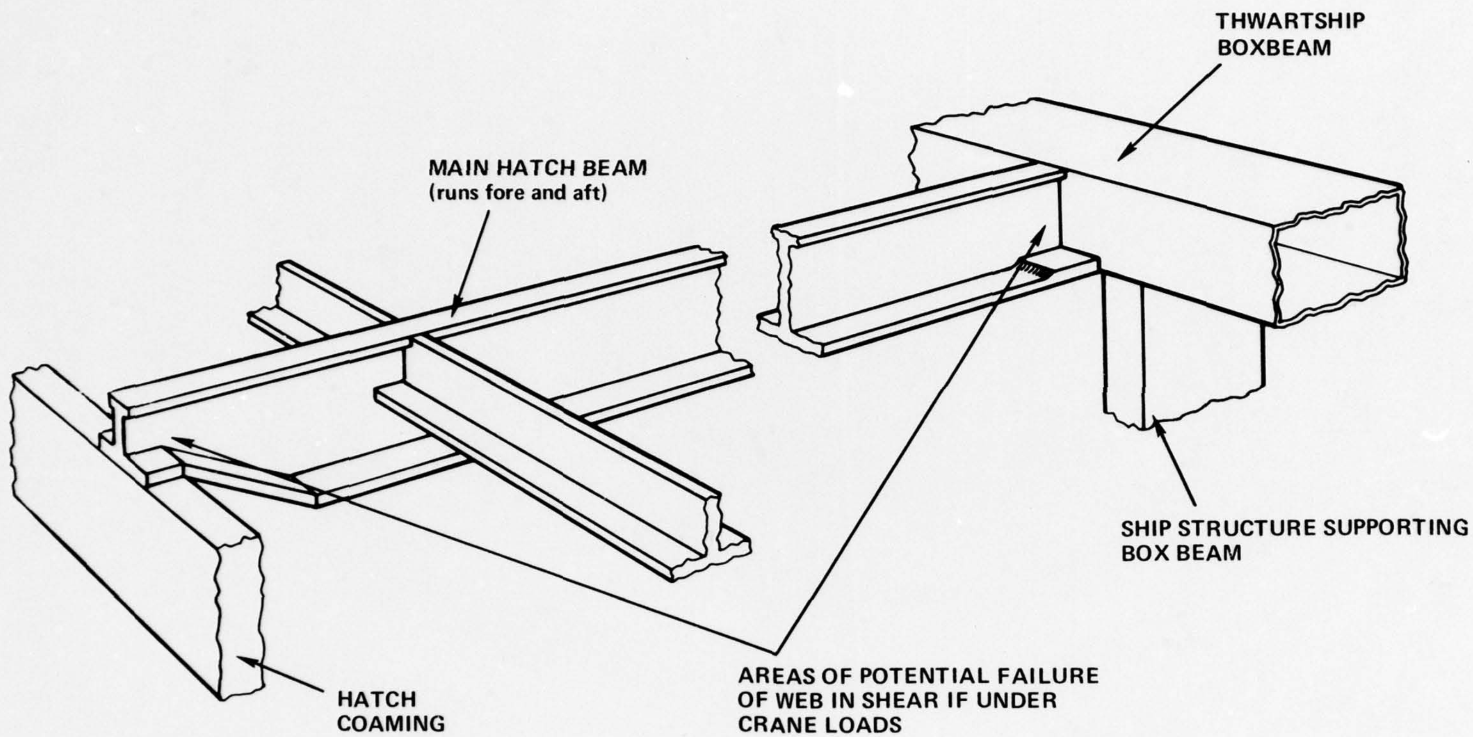

FIGURE C.6. SKETCH OF TYPICAL BEAM IN COVER OF DOUBLE HATCH FOR C685 SHIP

(9/32 inch plating covering hatch and details of overlap with coaming omitted for clarity.)

beam ends in a 35-ft long cross structure in the form of a box that, in turn, is supported by the special removable ship structure. (The strength of this box member and its support was assumed adequate for the loads being discussed. No calculations were made.)

A question addressed was this: Is the shear strength of the beam in the hatch cover great enough so that the bridging plates can simply be laid on top of the hatches, or must each bridging plate be supplied with steel or timber "abutments" at each end to transmit the load down to the deck and thence to the ship structure directly, instead of through the hatch cover beams? The answer to the question is that the web strength in shear is in fact marginal, particularly at the beam end supported on the coaming.[2] Abutment timbers are required.

Operating the Crane Near the Ship Centerline

To use the crane over the hatch tops for lifting containers, more stress has to be allowed for than in simply moving the crane. Stronger bridges must be used under the outriggers, The maximum load is 85% of the sum of the weight of the crane and the container. This is a concentrated load of 93 long tons, almost three times the wheel load allowed for above. First cuts at timber and built-up steel beam designs that would be suitable are shown as Figure C.7. Either would weigh about 5 tons. (The sketches in Figures C.5 and C.7 show beams that would support the bending load with no assistance from the hatch cover beams. Further investigation of the shear loads on the box-beam ends of the hatch beams would be necessary.)

MANEUVERING CRANE ON DECK

Hatch Coaming Height Above Deck

To move the mobile crane from one position to another on the ship deck, it will be necessary not only to bridge the hatches, as already discussed, but also to provide a raised platform for those parts of the weather deck where there is no hatch. American Bureau of Shipping rules specify that coamings generally be at least 17.5" high (with exceptions for hatches with steel covers made tight by means of gaskets and clamping devices). The C685 design of non-self-sustaining containership has hatch coamings 30" high. The fore and aft space between hatch covers is approximately 50" on this design. Thus, for fore and aft movement of the mobile crane some means of filling in this space must be provided. Timber balks such as were used for the same purpose in the OSDOC II exercise appear suitable. They would also serve to transfer the crane weight from the ends of the hatch-spanning beams to the deck of the ship (i.e., serve as abutments).

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[2] The customary allowable shear stress is 12000 lbs per square inch. The web at the small end is ½" thick and 10.16" vertically, and thus is 50.8 sq ins in area. The rear wheel loading, if considered concentrated, is 37.5 long tons, or 84000 lbs. Thus, the shear stress would be 84,000 ÷ 5.08 or over 16,500 psi instead of the allowable 12,000 psi. The load is not in fact so concentrated, and the stress may be spread somewhat to other hatch beams in a manner not determinable by the elementary calculations considered here. At the box beam end the web has a greater sectional area and the web shear is below the allowable 12,000 psi.

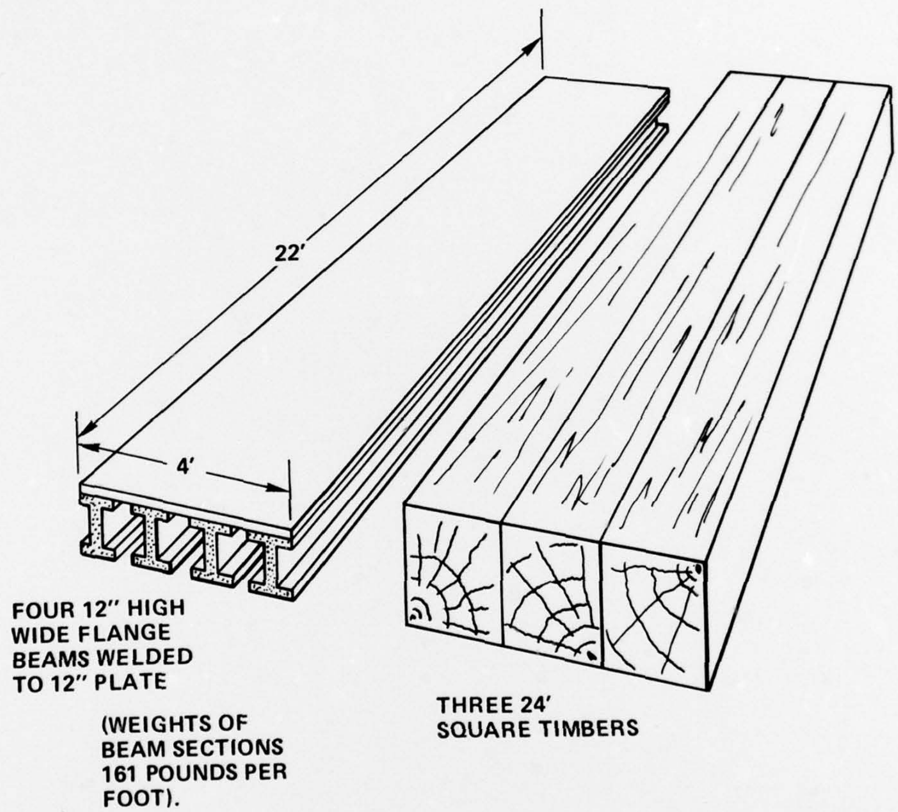

FIGURE C.7. BEAMS SUITABLE FOR SUPPORTING CRANE OUTRIGGER PADS

At the deck edge also balks could be used. For crane operations the timber under the outriggers could be spanned by the built-up beams already described for bridging hatches, one at the deck edge for the rear outriggers, and one across the hatch for the forward outriggers

The crane itself can be used to move the timbers. To keep from having a large number of small crane lifts, the timbers can be fastened together in convenient bundles.

Turning Crane on Deck

Between the deployment phase of a LOTS operation and the container unloading phase, a mobile crane on a containership would have to move and turn. For the heavy lifts, the crane carrier would be athwartships, while for container operations a position near the ship centerline, and parallel to it, would be most convenient. One way of accomplishing the repositioning aboard the C685 design ship is indicated in Figure C.8. It is a plan view of part of the deck, and shows the use of the built-up steel bridging plates, each 22' long x 15' wide.

The number of plates required is at least six. Initially the crane is supported by two, labelled 1 and 2 in the sketch. Four more are required so as to be in place for the crane to move onto. (These are plate locations 3, 4, 5 and 6. When the crane has moved on to 3, 4, 5 and 6, the plates in positions 1 and 2 can be repositioned to 1A and 2A, and the crane moved again. At the point where the crane reverses, the front wheels are on 1A and 2A, and the rear wheels on 4, 5, and 6. After the reversal, the plate in location 2A is moved to 2B.

Other ways of providing bridging for the maneuver could be considered. One would be longer bridging beams that are placed at appropriate angles and would thus presumable save material by more closely fitting the desired path of the crane. A difficulty with this approach is that longer spans require heavier material. A span that crosses the hatch at a 45^{o} angle, for example, would have to span not 20' but 28', and be correspondingly heavier in section. The bending moment for a specified load (and hence the needed section modulus) increases directly with the span. Between the extra weight per foot because of the increased modulus needed, and the extra length, each 28' beam would weigh twice as much as the 20' one.

Deflections increase with the cube of the span. For steel the deflection of a beefed-up bridging beam would presumably be acceptable. For wood the increased thickness required to keep deflection within reason may well make its use impractical. (Note too that timbers of lengths over 25' could be hard to procure.)

Another alternative would be to use specially strengthened hatch covers, including extra plating on top of the covers so as to increase the thickness above the present 9/32" used in the C685 design.

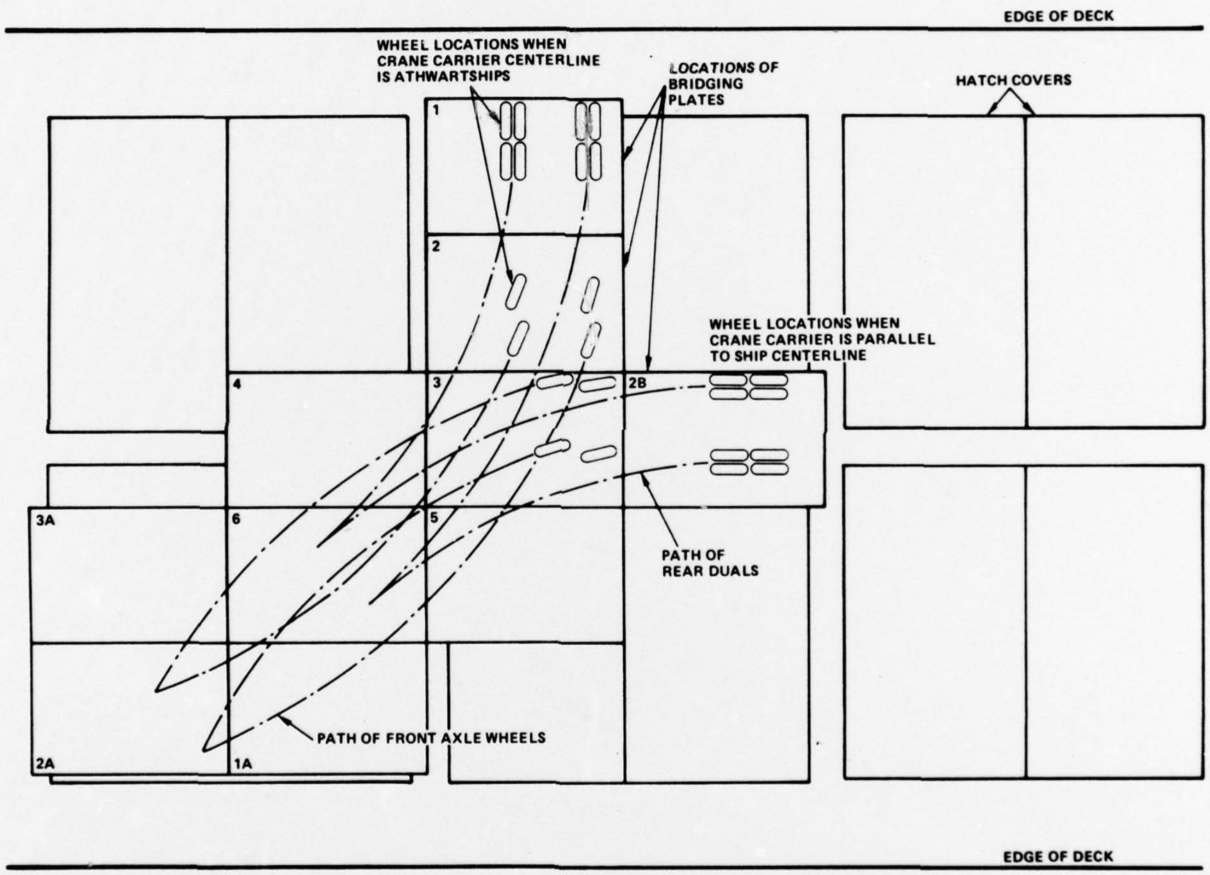

FIGURE C.8. TOP VIEW OF PORTION OF C685 DECK
(Shows use of successive positions of plates bridging the hatches as crane is maneuvered between athwartship and near-centerline position.)

APPENDIX D

STANDARD PORT SYSTEM (SPS)
(LOTS APPLICATION)
PRETEST

(TO BE PUBLISHED SEPARATELY)